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The SCIENTIFIC MONTHLY

July 1944

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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Founding and Organization

In 1848, on September 20, the Association was formally organized and held its first meeting; in 1874 it was incorporated under the laws of the Commonwealth of Massachusetts and given the right to receive, purchase, hold and convey property. Its governing body is a Council, now having 255 members.

The Association is national in scope, with membership open to the whole world on equal terms, and its interests include the broad fields of the natural and the social sciences. Its varied activities are carried on under 16 sections with which 189 affiliated and associated societies, having a combined membership of nearly a million, cooperate in organizing programs for its meetings.

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The Association's meetings are field days of science attended by thousands of participants at which hundreds of scientists vie with one another for the pleasure and the honor of presenting results of researches of the greatest benefit to their fellow men. An enlightened daily press reports their proceedings throughout the country.

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A world torn by conflicts and fearful of the future is looking more and more toward scientists for leadership. The opportunity for unparalleled service is theirs and the fact that they have available the only essentially new methods, if not purposes, imposes an equal responsibility. For these reasons it will be the Association's steadfast purpose to promote closer relations among the natural and the social scientists, and between all scientists and other persons with similar aspirations, to the end that they together may discover means of attaining an orderliness in human relations comparable to that which they find in the natural world about them.

MEET THE AUTHORS

Signal Corps, U. S. Army

MAJOR GENERAL JAMES A. CODE, JR., B.S., M.S., E.E., is Assistant Chief Signal Officer, U. S. Army, having been so selected because of his background, which has run through the entire realm of the art and science of communications. He is now stationed at the famous Pentagon, Arlington, Virginia, where he serves as Chief of Staff to the Chief Signal Officer. He was born in San Francisco in 1893 and grew up in that stimulating city. Graduating from the U. S. Military Academy at West Point in 1917, he served as an instructor in Coast Artillery and Field Artillery during the first World War. After the war, he remained in the Army and began his career in the Signal Corps. It is said that Army officers are continually getting or giving instruction. Certainly this was true of General Code, for the Army gave him the opportunity to study and to teach at three Universities. In 1920 he was among the first to receive Yale's master's degree in communications engineering. For the next three years he continued to study and teach at The Ohio State University and built the first broadcasting station at this university. He then applied his knowledge and skill in the Philippines, where, in addition to his work on radio and telephone communications, he laid submarine cable to Corregidor. After another year of graduate study, Yale granted him the degree of Electrical Engineer in 1933. Then followed four more years of teaching and studying at the University of California; more practice in Panama. Finally, General Code's years of study and practice bore fruit for the nation, as no one can doubt who reads his article. He arrived at the top Signal Corps rank of Major General on December 11, 1942, engaged in directing communications service of staggering scope and complexity. His hobbies of collecting old maps, building antique-style furniture, and playing golf are relegated to the future. It is not an anticlimax to say that General Code is a member of Pi Tau Pi Sigma and Scabbard and Blade, honorary military fraternities, and holds the Victory, American Campaign, and American Defense Service Medals.

EDWARD J. STIEGLITZ, M.S., M.D., F.A.C.P., practitioner of constructive medicine, is limned on page iii, preceding issue.

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By means of a series of journeys through the British Isles, the "long panorama of the earth's history is revealed in descriptions of the terrestrial phenomena which characterized different periods." This interesting book is designed to appeal to both the geologist and the layman.

Foundations of Plant Geography. STANLEY A. CAIN. xiv + 556 pp., illus. 1944. $5.00. Harper & Brothers, New York and London.

This extensive and detailed study of the science of plant geography (introduced as "a borderline science" because of its relation to other sciences) contains five parts: Introduction, Paleoecology, Areography, Evolution and Plant Geography, and Significance of Polyploidy in Plant Geography.

Index Fossils of North America. HERVEY W. SHIMER and ROBERT R. SHROCK. ix + 837 pp. Over 9,400 illus. 1944. $20.00. Massachusetts Institute of Technology Press. Distributed by John Wiley & Sons, Inc.

This imposing volume is a comprehensive treatise on those fossils best adapted for the determination of geologic horizons. Nearly all left hand pages are plates illustrating some 7,500 species, which are classified and described on the opposite pages—footprints of the march of time.

The Pacific World. Edited by FAIRFIELD OSBORN. 218 pp., illus. June 1944. $3.00. W. W. Norton & Co., Inc.

The Pacific, an area of the highest importance and concern to us today, is vividly presented in all its vastness and beauty in this very timely and readable book to those in the Armed Services and all other Americans. Maps, colored illustrations, and factual tables complete the extremely interesting text.

One Hundred Years of American Psychiatry. Edited by J. K. HALL, *et al.* xxiv + 649 pp. 35 illus. 1944. $6.00. Columbia University Press, New York.

Thirteen distinguished contributors present this handsome volume in commemoration of the centennial of the American Psychiatric Association, the oldest national medical organization in America. Conceived in 1941 in the midst of world crisis, the result is a fine synthesis of a century of American psychiatric evolution.

A Source Book of Agricultural Chemistry. CHARLES A. BROWNE. x + 290 pp., illus. 1944. $5.00. Cronica Botanica Co., Waltham, Mass.

The history of agricultural chemistry from ancient times to the time of Liebig, most outstanding figure in this field, is presented in scholarly fashion in this very detailed work. The many illustrations and references make the book a valuable source of information on the origins of agricultural chemistry.

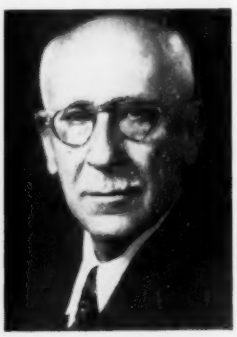
Asia's Lands and Peoples. GEORGE B. CRESSEY. vii + 608 pp. 350 illus. 1944. $6.00. Whittlesey House, McGraw-Hill, New York.

Beautifully illustrated, this encyclopedic survey of "one-third the earth and two-thirds its people" is divided into sections on China, Japan, Soviet Union, Southwestern Asia, India and Southeastern Asia. It is a valuable guide to an understanding of Asia by an America functioning in a global world.

* Orders for the books noticed above should not be sent to THE SCIENTIFIC MONTHLY or the A.A.A.S., but to your bookseller or the publisher.

MEET THE AUTHORS, Continued

CHARLES I. GLICKSBERG, Ph.D., is a teacher of English at South Side High School, Newark, New Jersey. He was born in Warsaw, Poland, in 1900. Growing up in New York, he directed his education toward Medicine and finished his premedical course at the College of the City of New York. Thus we account for his interest in science. But Literature eloped with him at the last minute and took him to Columbia for an M.A. In 1932 he received his doctorate from the University of Pennsylvania. Some men can write but have nothing to say; others have a message but cannot write. Dr. Glicksberg has a superior combination of knowledge, ideas, and writing talent, with which he has graced many relatively nonremunerative magazines. He is also the author of a book, *Walt Whitman and the Civil War*. We expect to hear more of Dr. Glicksberg.



JOHN CLAYTON GIFFORD, D. OEc., is Professor of Tropical Forestry at the University of Miami, Florida. As Hannegan boosts the bathing beauties of Miami, so with the same enthusiasm, but with dignity, does Dr. Gifford extol the beautiful and useful trees of his adopted State. It is his mission to make the nation conscious of the value of his trees so that he may leave them flourishing as his legacy of a long life of service to the conservation of our natural resources. Dr. Gifford was born at May's Landing, New Jersey, 74 years ago. He is a graduate of Swarthmore and took his doctorate in forest economics at Munich, Germany. Prior to settling in Florida, he studied the forests of New Jersey, taught at Cornell, and surveyed the Luquillo Forest Reserve of Puerto Rico for the U. S. Department of Agriculture. He has traveled extensively in tropical America and is a prominent citizen at home. Perhaps the oldest graduate forester in the United States, Dr. Gifford has served his profession and his country with distinction.

MEET THE AUTHORS, Continued

Leia Gorska

CHARLES MORROW WILSON, B.A., is a journalist and writer, now associated with the Office of the Coordinator of Inter-American Affairs. His address is 597 Fifth Avenue, New York, N. Y. A native of Fayetteville, Arkansas, he was brought up on a small farm near this town and was graduated from the University of Arkansas in 1926. His interest in agriculture was increased by study in England in 1929, and much of his writing has been concerned with rural and agricultural subjects. His interest in tropical agriculture dates back about eight years and is supported by first-hand reporting and farm appraisal for the United Fruit Company in Cuba, the countries of Central America, Colombia, and Jamaica. Mr. Wilson has long since arrived as a writer. He has worked for three of the country's best newspapers, has contributed to the leading magazines, and has written more than eight books, the last of which, *Middle America*, was released on April 25, 1944.

C. K. TSENG, Sc.D., is engaged in research on seaweeds at the Scripps Institution of Oceanography. His biographical sketch and previous article on agar may be found in the issue of January, 1944.

M. F. PERUTZ, Ph.D., is engaged in research on proteins at the famous Cavendish Laboratory of Cambridge University, England, where he also lectures. He graduated from Exeter House College, Cambridge, in 1940, one year after his appointment, at the age of 25, as research assistant to Sir Lawrence Bragg under a grant from the Rockefeller Foundation. Later he worked for a year with Professor J. D. Bernal on a war project. He has published several papers on the structure of the haemoglobin molecule and has the faculty, so marked among British scientists, of making difficult subjects understandable to laymen. His hobby is mountaineering, with which he has combined a study of glacier motion.

M. F. ASHLEY MONTAGU, Ph.D., is Associate Professor of Anatomy at the Hahnemann Medical College, Philadelphia. See the January, 1944, issue for more information about this ball of fire and his previous article on the American Negro.

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BIOLOGICAL ABSTRACTS

University of Pennsylvania

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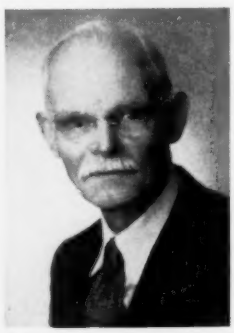
MEET THE AUTHORS, Continued

ALFRED GUNDERSEN, Docteur de l'Université, Paris, is Curator of Plants in the Brooklyn Botanic Garden, where he came thirty years ago from the Arnold Arboretum in Boston. He was born in 1877 in the little coast town of Kragerö, Norway, where he early developed a love of nature. He is a graduate of Stanford, Harvard, and the Sorbonne. He has travelled widely in this country and in Europe and has visited botanic gardens in many countries. Dr. Gundersen has published on the history of botany, and on trees and lilacs. He is noted for his publications on flower structures and on the classification and evolution of dicotyledons. His interests are not confined to botany, but range among astronomy, calendar reform, paleontology, and glacial effects, the last especially in the Catskill Mountains, where he grows vegetables at his summer home.



GEORGE T. HASTINGS, M.A., is a retired botanist, now living at 842 Nineteenth St., Santa Monica, California. He was born in Bath, New York, in 1875 and was educated at Cornell and Columbia. After teaching for three years in Santiago, Chile, Mr. Hastings began a thirty-year career as teacher of biology and botany in the New York City High Schools, rising to the chairmanship of the Biology Department of the Theodore Roosevelt High School. For twenty years he was editor of *Torreya*, published by the Torrey Botanical Club of New York City where he and Dr. Gundersen became friends. For six summers Mr. Hastings was on the staff of the summer Nature Camp of Pennsylvania State College. Since his retirement, he has completed a small book on the trees of Santa Monica, describing some 300 species and telling where good specimens of each can be seen in the city. Collaborating by mail on their present article, Dr. Gundersen and Mr. Hastings took the greatest pains to develop it into a coherent story of evolution.

THE SCIENTIFIC MONTHLY

JULY, 1944

SCIENCE IN SIGNAL CORPS DEVELOPMENT*

By JAMES A. CODE, JR.

WHEN it became evident that the world was going to war, there was no class in this country that started to mobilize more quickly than the scientists. During twenty-five years in response to technological advances we had revolutionized our habits of eating, transportation, clothing, entertainment, and communications. It was clear that our methods of warfare must be similarly revolutionized; our scientists and engineers were among the first to recognize that this must be so, and offered their services to that end. They asked only that the Armed Forces define the needs for them to supply.

The decision as to how they could best be used was largely a military problem. It was not a problem that could be solved once for all. Even if it were possible to forecast the entire course of a war in advance, it must pass through varying phases wherein the emphasis on the use of science and scientists will shift. Without such foreknowledge the problem becomes much more complex and uncertain.

Every soldier wishes that, when war does come, he could enter it with his arms and equipment fully developed and in full production. Only in a wholly militaristic country, bent on conquest, is this even approximately possible; in a democracy it is entirely out of the question and therefore, when the European war did come in 1939, we started from scratch. This meant that we had to carry on simultaneously all the consecutive steps of technological progress from basic research, through invention and development, to production.

Nowhere has this been more evident than in the Signal Corps, for we are now using, daily, effects that were only hopes five years ago and that we certainly did not then know how to produce. When we have developed a new technique, we must at once find means to combat it if it should be turned against us, as it certainly will be if the war continues long enough, and so research, invention, and development must continue side by side even after our Army is fully equipped.

At the moment our only mission is to win *this* war. Our most fundamental need to that end is scientific brains to carry out every one of the steps from basic research through production, for it is not until the last step has been taken that the first step contributes its share toward the objective.

We can conceive of someone, after the war, drawing a family of curves showing the value to the war effort of research, invention, development, and production in accordance with the epoch of the war at which they were carried on. Such curves would rise successively to their peaks, hold these peaks for a while, and then decline until the first of them, research and invention, assumed negative values, these activities having diverted manpower from others, while their results were achieved too late to be used in the field.

In actuality, however, such graphs would mean little or nothing. In the first place, we have no knowledge as to the time scale. More important, however, is the fact that it may be the last development to come into use which by achieving strategic or tactical surprise wins the decisive battle and ends the war. Timeliness may be of far greater value than extent of use.

Discounting our graphs, however, we can still see that the process from research to production passes through various phases

* An address, with certain omissions, presented before a closed meeting of the National Academy of Sciences, Washington, D. C., April 24, 1944.

and although we cannot state at what instant we pass from one stage to another, we can state that the first phase is now definitely past. We are beyond the point where we merely knew what technological results we wished to accomplish and were supported only by an inner confidence that we could devise and produce the equipment with which to do it. We have reached a stage where we can produce, and are producing, equipment as fast as we can train men to use it. We know, by experience, that our equipment is, in general, as advanced as any in the world. Therefore, a change in emphasis has taken place in our development program. What this change in emphasis means can best be appreciated by a few illustrations of what has been accomplished in the earlier phase. In 1934 the Signal Corps was given by Congress $170,080 for its entire research and development program. This total budget was approximately equal to our present annual expense for friction tape to insulate the splices in our wire. That year it became evident that Hitler was preparing for war, and so in the following year we were given about $42,000 more with which to start advanced electronic development. The increase amounted to about the present unit price for quantity production of one of the pieces of equipment resulting from that development.

Budgets, however, increased explosively after war started in Europe, and by the time it reached us on December 7, 1941, we had a limited number of detection equipments of two types in actual use. Since then many new types of electronic equipment have been developed, some of it for purposes not even conceived before the war, and based on research done and inventions made since the war started. There are records of well over 500 inventions rising out of Signal Corps projects alone which are of major importance because of broad scope or extensive production, without taking account of any whose value remains to be proved. Navy has at least as many more in the same fields and the contributions of our allies and our own industrial laboratories cannot even be estimated until after the war is over and all records become available.

Although there have been spectacular developments in classified electronic items, this has not been at the expense of other components of signal communications equipment. Before the war we had radio communication equipment that seemed, if not entirely adequate, as good as was likely to be forthcoming. Today we are producing different types of radio sets for infantry, artillery, and tank use, inter-plane and plane to ground, for parachute troops and amphibious forces, radio telephone, telegraph, and facsimile, mobile and fixed station, frequency modulated and amplitude modulated. Only one of the radio sets now in production, however, is of prewar design. New tactics and an advancing art have demanded that the others be redesigned or developed from the ground up.

I spoke a moment ago of "extensive use," but we have given these words a new meaning. Our *monthly* receipts of radio equipment are half again as great as the yearly prewar output of the entire industry. For that equipment we are paying, monthly, as much as the entire cost of the Panama Canal. The fixed plant of the Signal Corps' radio system today exceeds greatly the total of such equipment in the world before the war.

Merely to produce such expansion of manufacture was a technological problem of heretofore unparalleled proportions, and research and development had to compete for manpower and materials with those who were undertaking greatly expanded production to new standards of tolerance. While we were having made, monthly, enough telephone wire to encircle the earth ten times, we were confronted with the problem of learning to insulate it with synthetics instead of natural rubber. While expanding the production of quartz crystals 500-fold, we had to develop new types and learn to keep them from aging.

I have said that "we" did these things, but by that I do not mean the Signal Corps but the *team* formed by the scientists and engineers in industry, the universities, the Navy, the NDRC and OSRD, and the Signal Corps, and the role of the latter has been more and more merely to assign the problems for you and your confreres in civilian life to solve.

It is because of such accomplishments as

have been mentioned that I say the first phase has passed. Even if we wished to do so, we could not put the results of new research and development into production at the rate we have been doing in the past three years. The facilities, the materials, and the manpower to do it do not exist. Moreover, for the moment, we have solutions to most of our basic problems.

Not all of them, of course. As yet, I cannot see through a mere six inches of earth to identify a nonmetallic antipersonnel, or antitank, mine. If you would give me the means to do that, you would save untold lives; if you would go further and show me how safely to destroy the mines when detected, you would save thousands more, not only directly but by restoring to our troops the mobility that the mines now curtail.

Or if you would give me a dry cell that would operate at stratosphere temperatures without too great loss of power, or insulation for wire that would not become brittle at like temperatures, you would deserve the gratitude of a nation. Or give me a sound powered telephone with a talking range equal to the externally powered variety. These represent a few of the things that remain in the first phase of development; we have not *a* solution, much less *the* solution to problems such as these.

No contribution that could be made at the moment would be more welcome than a really satisfactory source of power. We are not proud of the fact that our small gas engines weigh twenty to thirty pounds per horsepower, as against four-tenths to six-tenths for aircraft engines. A small engine that would operate satisfactorily on leaded gas, or even a simple method of deleading gas, would help a lot. In all of our power sources, we need improvements beyond mere refinement; improvements in performance running to higher orders of magnitude. You have given such an improvement to us in dry cells for tropical use, but nowhere else in the power field that I can think of.

I might digress to point out here that an improvement in the order of magnitude in any line frequently has an impact that goes beyond its immediate field and affects almost all lines of endeavor. The radio relay has made a saving of that order in manpower for construction and maintenance which may mean that communications can be established where they were impossible before. The tropical dry cell gives us more shipping space and may mean an all-or-nothing difference in maintaining communication when the going is tough. And new orders of magnitude in precision of dimension or of frequency stability have their effect in every field of science. Research and development growing out of this war have given such improvements in several fields.

Apparently minor developments or improvements may create disproportionate and even spectacular results. For instance, before 1941 the smallest radio transmitter, the radiosonde, was highly uncertain in operation—nearly 90 per cent failed. The famous blond-hair moisture unit was then discarded for a plastic device and a tiny ceramic resistor was developed to measure temperature. The resulting radiosonde (costing only $24 complete with balloon, parachute, and temperature, moisture, and pressure units) always worked, as military equipment must. The importance of this is illustrated by the record of an 80 mm. mortar, firing through overcast. A ground wind was blowing at 12 miles per hour. A radiosonde, however, showed that along the trajectory there was a 213-mile wind, which *only* it could have detected. The incredulous artillerymen, reluctantly and under protest, made a correction of 4,000 yards (over 2¼ miles) in their firing data. Closing their eyes, they shudderingly and prayerfully jerked the lanyard and found, to their amazement, that the projectile landed on the target instead of on their own troops.

Returning to the present phase of our program, the role of development is twofold: first, the improvement and refinement of present equipment; and second, the devising of countermeasures.

Improvement may mean many things, but increase in reliability comes first; and performance, increased range, or accuracy, second. Simplification in manufacture or use is desirable to curtail materials, manpower, and training time, but the importance of simplification can be overemphasized. We now have manufacturers who know how to make, and troops who know how to use,

equipment of high precision and complexity. It is less of a task today to teach the manufacture and use of more complex equipment than it was the manufacture and use of relatively simple gear two years ago, and hence if reliability or performance conflict with simplicity, it is simplicity that will be sacrificed.

I have already referred briefly to countermeasures. Our first approach is to combat the techniques we ourselves have developed on the theory that the enemy will use the same ones eventually if not immediately. Our next step is to find means of combating the enemy's deviltries as fast as he produces new ones, and to concoct still newer deviltries of our own for use when he solves those we are using now.

In the present stage of our development program, both as to refinement and countermeasures, field experience is of utmost importance. That experience is gained in two ways. The first is through reports sent to the laboratories by field units, or gathered by liaison personnel sent to the field from the laboratories. Second, and more important, are the laboratory teams operating within the theaters of operations, and the scientific officers attached to the staffs of combat units. Development has thus moved nearer the front, while research has moved back, entirely into the hands of civilian agencies.

Development must maintain its present status with respect to the Signal Corps up to the surrender of the last enemy. We shall never know when it enters on the phase of declining usefulness shown on our hypothetical graphs, and attempts to forecast that phase are too dangerous even to contemplate. We must remember that Hitler thought he had entered the final phase of his war in 1940 and again in 1941. He entered the war with the idea that he could finish it with the same equipment with which he started. He learned better, and he now has large numbers of highly efficient people thinking up unpleasant surprises for us. The enemy may spring those surprises up to the last minute, and up to the last minute we must be ready to counter them. Somehow we must find a way to continue to use our scientific manpower with undiminished effectiveness, for it is our one irreplaceable resource for which there is no substitute. We must maintain our research teams until the last shot is fired and after, for otherwise we may find that what we thought was the last phase was merely a breather before a new and more deadly resumption.

Therefore, even from the superior knowledge of hindsight, we should not assign negative values to research and development in any phase of the war, any more than business can regret after the fact that insurance premiums did not result in payment of claims not made. Moreover, while it is true that we have but a single mission, when the final phase does come, we shall have a new and equally important one—the prevention of the next war. I hope that we have now learned that preparedness is the best preventive, and our unused techniques will be a major contribution toward that end.

If we are wise, therefore, research and development of much the present type will continue. If so, the present partnership between science and the military will not be dissolved, and neither will be completely demobilized. If that plan is followed, we may be able to postpone the "next war" indefinitely.

SENESCENCE AND INDUSTRIAL EFFICIENCY*

II. SPECIFIC PROBLEMS

By EDWARD J. STIEGLITZ

PERSONNEL executives are concerned with developing policies in connection with certain specific aspects of employment of older individuals. These include the problems of selection of new employees, the question of accident hazards in relation to age, the complex field of placement, the emotional hazards of senescence as seen industrially, and last, though by no means least, the critical problems of key personnel.

SELECTION

Policies concerning selection of new employees are rarely static. Wide fluctuations in the labor force available affect the attitude of personnel officers profoundly. Always, there arises the question of balancing risk introduced by lowered physical fitness against exceptional and valued skills. This question occurs far more frequently with older applicants for employment, for it is these men who have developed exceptional skills and who also have lived long enough to have acquired many physical impairments. The significance of defects varies greatly with the occupation. Extensive and immensely valuable studies have demonstrated that even those with severe physical handicaps are safely and profitably employable. That many such will have to be employed is certain, for our returning war casualties have the right to work. Present-day pre-employment physical examinations are quite adequate, in most instances, to insure against placing workers in occupations where their defects render them a hazard to themselves, to other workers, or to the public.

However, there is one serious flaw in present classifications of physical fitness. There is insufficient distinction between static defects and potentially progressive impairments. Fitness implies more than ability to work safely and usefully today; it implies promise of continuing capacity for such work. The man with one eye, with an artificial leg, or minus several fingers presents permanent but stationary defects, the significance of which diminishes with time as he acquires skill in handling himself and in compensating for his handicap. In contrast, early hypertensive disease (high blood pressure) implies no immediate jeopardy or hazard, but does indicate progression of the disorder with persistently increasing impairment of health and efficiency. Contrary to the usual impression, the younger the individual the more rapidly will such disease progress. A moderately severe hypertension in a man of fifty-five constitutes an employment or insurance risk less hazardous than a mild or early instance in a young man of twenty-five or thirty.

ACCIDENT HAZARDS

The question of accident hazards in relation to age can be dismissed quickly. Casualty insurance rates are not affected by employee age. Though the severity rate of accidents increases with age and longer periods are required for repair and recuperation, the frequency rate of disabling accidents falls to such an extent that the two elements effectively cancel each other. Reduction in frequency of accidents is due to many factors, including greater skill, greater caution, lessened horseplay, and greater familiarity with the hazards of the specific occupation. Except in occupations requiring exceptional agility and speed of muscular coordination, senescence can be ignored as contributing appreciably to the accident risk.

PLACEMENT

Placement of senescent employees is a much more complex question. Training and previous experience, skills, and physical fitness are still the basic guides to proper placement. Techniques for determining aptitudes and potential skills have been developed to a fine art. Many organizations now go to great length to insure that new young employees are carefully screened so that each shall be fitted into a niche appropriate to the

* Continued from p. 414 of the preceding issue.

contour of his character and capacity. This is splendid, so far as it goes, but it does not go far enough. For, all too frequently, once the peg is carefully fitted into the proper hole, it is left there and forgotten. As time goes on, the job remains the same but the man does not. He changes with age. As he changes, the fit between man and job often gets worse and worse. Consequently friction arises: friction causes inefficiency in the operation of the human machine as in any other. Work accomplished is reduced and the worker is affected to his detriment by emotional stresses, the origin of which both he and his foreman usually fail to recognize. Resentment and a growing sense of futility soon play havoc with production. Criticism results either in resignation or in escape through development of neurotic complaints of physical ills to account for growing inefficiency. Physical and mental health are inseparable; man is a single, though complex unit. High labor turnover and neuroses are the two nightmares which accelerate the senescence of personnel executives more than any other. Both employer and employee lose; there is much waste here.

Recognition on the part of personnel and supervisory officers that aging brings about changes in men's speed, endurance, outlook, interests, enthusiasms, judgment, muscular strength, visual acuity, and sense of responsibility can do much to reduce the ill effects of bad job placement. If the fit between man and job is to be maintained over the years, then the job must be changed as the man changes. Some will say this is impossible and utopian. But it is not. In this war emergency "in-training" of new employees to equip them to handle new and often complicated jobs has proven brilliantly effective. Is there any reason why modified in-training for new jobs more appropriate to changing capacities cannot be continued for old employees? A small percentage of time can well be spent from 20 to 30 to learn how to tackle tasks more appropriate after 30; in the next decade by preparing for the changes inevitable after 40; and from 40 to 50 preparation for the sixth decade becomes an even wiser investment of time. Nor is there need to stop here.

Such continued education has immense potentialities in all walks of life and all occupations. It will answer one of man's greatest emotional needs and thus release much of his energy, often diverted by frustration, to useful accomplishment. Everyone of us requires some sense of progress, the feeling of at least a little forward motion. Without it the drive of ego gratification vanishes and man becomes an automaton. For work that can be done by an automaton, there are machines that can probably do it better. From the point of view of modern industrial production the greatest difference between man and the machine is that man is versatile, whereas the machine is not. Versatility, permitting the development of multiple skills, is a precious element of our human resources and should be cultivated. The long-standing practice of rotating officers in different tours of duty during peaceful periods reveals the value placed upon versatility by our Army and Navy. Industrial personnel policies have been largely in the opposite direction, toward specialization and, therefore, toward limitation. Specialists are fine, even in medicine, but there must not be too many of them, nor their disciplines too highly refined.

The first and loudest objection which will be raised against this suggestion is that "you can't teach an old dog new tricks." It is invalid because the assertion is utterly false. This erroneous concept has already done immeasurable harm and retarded man's development of man more than any other influence. There are several factors which account for the perpetuation of this vicious notion: it becomes a useful alibi for intellectual indolence in later years; it has been fostered by youth, which proverbially is certain that it "knows it all;" and it has saved from embarrassment many who thought to teach the aging and the aged, for they forgot that in order to teach an old dog, one must know more than the dog! Careful scientific studies of the rate of learning in relation to age have conclusively demonstrated that the depreciation is very minor, once the inertia introduced by this false concept is removed. The rate of learning at eighty is about the same as at twelve, with the peak at twenty-two. Disuse of the faculty of learning depreciates one's ability to learn far more than

age per se. If no effort to learn is made after cessation of formal schooling, the ability quickly atrophies; if the practice of study is continued, it declines very slowly.

Emotional Hazards

Senescence introduces certain psychic and emotional influences into our lives which are significant from the point of view of working efficiency. Emotional equanimity is necessary for the continuance of health. Mental turmoil, particularly if long continued, is an active factor in the causation of many physical disorders. Neither the depressed nor the excited individual can work effectively.

Senescence brings about certain intrinsic changes in personality which occur irrespective of environmental conditions. As we grow older loyalty tends to be strengthened, although it may not be as passionately vociferous as in youth. Our sense of responsibility increases very definitely. The tendency to be distracted by minor and irrelevant occurrences diminishes. A lessening of ebullient spirits diminishes the tendency to indulge in horseplay and practical jokes. With accumulation of experience, judgment improves as the years roll on. All these changes are to the good and are indicative of further maturation. Partially counterbalancing these benefits is a tendency toward increasing fixity of mind. Such rigidity of personality is affected greatly by the habits of the individual in preceding years and is particularly prominent in those who have been required to do the same thing in the same way year after year. As we are all creatures of habit, the rigidity of our habits is determined by the frequency of repetition of an act, whether physical or mental. This tendency accounts for the frequent utterance by the elderly of such comments as, "the good old days," "the old way was just as good," and "these new-fangled notions!" We do not hear such remarks from elderly individuals who have been involved and associated with changing techniques and changing ideas. There is little qualitative change in personalities with aging, but rather intensification and fixation of long-standing characteristics. The talkative salesman becomes more garrulous, the curious research scientist becomes more curious still, the opinionated zealot becomes an intolerably bigoted fanatic, and the tolerant, wise director acquires increasing understanding of personalities.

These are the normal changes that occur in personality with senescence. Industrial employment frequently introduces anxieties which may upset the normal progression of an aging personality. The main factor disturbing the older worker is insecurity arising from uncertainty of employment. This is particularly disturbing to those who for one reason or another are unemployed or are likely to be dismissed after fifty. The difficulty of the older man in obtaining new employment has been so great that this sense of insecurity was quite justified. Social security programs and unemployment insurance do not solve the problem of maintaining emotional equanimity. All of us need something more than merely monetary return from work; there is an urgent, though often subconscious, need to feel useful.

Boredom and monotony are dangerous to good mental hygiene. Boredom may affect people of any age. But its consequences are more insidious and progressive in older individuals than in young people. Boredom is less a problem of employment than it is of unwise utilization of leisure.

Another hazard to emotional balance is inadequate promotion. Lack of promotion may be entirely justified because of the work record of an individual but it is just as disturbing to him as if it were a true injustice. He feels that he is being left behind, becomes excessively conservative and increasingly jealous of his years of service. It is against human nature to expect more than a very few individuals to admit that failure to be promoted is due to their own inadequacy. Particularly hazardous are anniversaries of employment, such as occur at ten years or twenty years of service. These make for introspection and dissatisfaction with the personal progress accomplished. Wise counseling, encouragement at just the right moment, and recognition of service by some appropriate celebration or symbol are of great value in diminishing this emotional hazard.

Less frequent but much more dangerous and expensive to Industry is the emotional hazard arising from excessive promotion.

Every individual has definite limitations, a ceiling to his capacity to carry responsibility as well as to do physical work. Not infrequently a man may rise from the ranks and reach the ceiling of his intellectual capacity rather early in life; perhaps in the early forties. Promotion beyond this point creates intense anxiety-states and quite possibly severe and disabling neuroses. A common problem of this type arises in the shop where an unusually able mechanic is made foreman and thus abruptly given the responsibility of controlling men instead of machines. Such a task may be beyond his capacity; subconsciously he recognizes that he is having increasing difficulties and is failing in his new responsibilities, which he was once so proud to accept. Several courses are open to him to bolster his ego and protect him from the pain of admitting failure. He may begin to shout and to bully, he may develop some physical complaints which excuse his inadequacy to himself, or he may become downright unhappy without knowing why. This type of situation interferes greatly with production, if it is often repeated. It is even more common to see such emotional conflicts in personnel doing intellectual rather than physical work. The executive in a position too big for him endangers both his own health and that of the business. Though demotion to work more nearly within the individual's capacity is the obvious treatment, it must be carried out with infinite tact if serious emotional crack-ups are to be avoided.

Another source of emotional turmoil that may make difficulties for the senescent worker is the climacteric or change of life. As a rule this period is more upsetting and difficult for women than for men, but we must not forget that it occurs in modified form also in the latter. The masculine climacteric is often sadly misinterpreted by supervisors with the result that the disturbance is decidedly aggravated. In the male we are more likely to observe difficulty in manual than in intellectual workers, perhaps because of the mistaken notion that virility and sexual vigor are an index to health and physical strength. These cases require wise psychiatric handling and should be studied by the medical service of Industry before disciplinary action or supervisory criticism is offered.

The last major emotional hazard associated with industrial health is that connected with obligatory retirement. At first glance it would appear that this need not concern those interested in maintaining work efficiency, because after retirement work efficiency no longer is of interest to the employer. But a little thought will show that anticipation of inevitable retirement induces turmoil long before it becomes an actuality. Rigid rules requiring retirement at certain chronologic ages accentuate this. As we have previously suggested, it is stupid to use chronologic age as the sole criterion in determining the wise time for retirement. To do so produces a double source of waste. It makes almost obligatory the retention of many men who have become senile prematurely and therefore functionally ineffective and it also wastes the productiveness and valuable services of many men in whom senescence is slower. It would be hard to judge which of these forms of waste is the greater. Certainly the retention of deadwood in positions of responsibility, or where imagination and initiative are valuable attributes, can be a very serious matter. Employees occupied with purely routine tasks are less detrimental to production when retained too long.

From the point of view of the individual, premature retirement while still vigorous, ambitious, and anxious to serve, can be a major disaster. It is an old axiom of clinical medicine that forcing the "one-track-mind" executive to retire is tantamount to signing his death certificate within the year. Unless there is definite and deliberate preparation for the constructive utilization of the sudden leisure, the acute boredom may be deadly. It is sad but true that it is often the men with the greatest drive and unity of purpose who are prone to break under these circumstances. Only lazy men or those who have multiple constructive interests welcome retirement.

Correction of the error of basing retirement on the arbitrary figure of chronologic age is relatively simple. Instead of absolute uniformity there can be variability, based upon highly individualized medical, including psychiatric, evaluation of each individual's fitness to continue in employment on a

specific assignment. Such evaluations must be extremely thorough and cannot be routinized or carried out in a production-line manner. The medical recommendations should be correlated with the strains, responsibilities, and hazards of the individual job. In most instances complete retirement will not be necessary. We should apply the principle that job assignment should be made to fit the man as he changes with age. Senescence is gradual; even more gradual than growth at the other end of the life span. Biologic changes, other than those of disease, are never abrupt. It is truly absurd to say that a man of 64 years and 364 days is capable of doing a responsible and important job and that 24 hours later he is "too old to work."

Key Personnel

Senescence of key personnel poses the most important questions of all those considered here. By key personnel we mean all those men who by reason of knowledge, experience, or skills are difficult to replace. Such men are almost invariably senescent individuals. Wisdom and judgment are conditioned by experience and knowledge which it takes time to acquire. Key personnel include executives, scientists, engineers, and designers. The greater the specialization, the more difficulty will be encountered in replacing such men. Per unit, key personnel are immensely valuable. Their value to Industry is reflected in the grave and heavy responsibilities assigned to them. This extra burden of responsibility obviously makes for additional wear and tear and thus places the most precious units in particular jeopardy. It is good business to insure valuable and productive tools against damage as well as against loss.

Therefore, health maintenance of these men is an integral and essential part of industrial medicine. By health maintenance we imply maintenance of work efficiency. The primary objective is not personal assistance. The job is, and should be, more important than the man. The idea of seeking medical guidance and reporting minor, but possibly significant, symptoms is often pathetically abhorrent to the rugged individualists who are the men that really count. They frequently resent the idea that their health is anybody's concern but their own. Nevertheless, their health and efficiency are the concern of personnel management in the same sense that the efficiency of a fleet of trucks or a battery of expensive and complicated machines is part of plant maintenance. We do not grease our cars and have them overhauled periodically because we feel any particular love for them, but because we want to get as many miles as possible without expensive breakdowns. Though the "tired business man" has been the butt of many jokes, it is no joke that his weariness impairs his efficiency. Brain power is the most precious part of man power. Because of these and other reasons we maintain that attack on the problems of senescence in relation to industrial efficiency should start at the top.

Health is always relative; never absolute. There is always room for improvement. We have outgrown the old definition of health, which stated that health was the absence of disease. This definition is far too limited. Perfect health is an abstract and unobtainable ideal. Health has quantitative attributes involving reserve capacities both in the physical and mental aspects of life. The old definition of health paralleled what statisticians call the mean or average normal. The new concept suggests an optimum state.

The function of medical care under the old definition of health was primarily to cure or alleviate disease. With the broadening viewpoint of what constitutes health, there is an equivalent broadening of the objectives of medical practice. The alleviation of disease might be likened unto the reconstruction of health. When we realize that health is always relative, we can immediately appreciate the possibility for improvement in the apparently well but actually only partially healthy individual. For this type of medicine we have suggested the term *constructive medicine*. The objective of constructive medicine is to bring the level of individual health as close to the optimum as possible.

Obviously, the prerequisite to improvement to any state of relative health is an analysis of the present status. The keystone of the bridge to greater vigor and effectiveness is the periodic health inventory and its bridgeheads are thoroughness and individualization. The choice of the term "inventory" is intentional because so many have abused

and limited the meaning of the phrase, "periodic examination." Health inventory includes as essential elements study of the past history of the individual (it must be remembered that we are today because of what we went through yesterday), a clinical physical examination, certain laboratory and x-ray studies, and investigations into certain functional reserves. Not until all these data are available can a usefully accurate appraisal be made of the state of health or the approximate physiologic age. No business man expects an inventory or annual audit of the state of his business to be accomplished in a few minutes. Nevertheless, it is all too frequent that senescent individuals laboring under great stress and tension will ask the doctor, "Listen to my heart, Doc, and tell me how I am today." This cannot be done.

Reserve capacities to carry increased loads are very difficult to measure unless one creates conditions of stress. We cannot judge the reserve capacity of an automobile motor by listening to it idling at the curb. Driving the car up a steep hill will reveal the reserve power. The situation with respect to the biologic capacities of man is quite parallel. Ordinary examination of the heart does not reveal its capacity to take on a burden of violent effort.

The principle of periodic physical examinations has fallen into disrepute in many quarters, not because of any weakness of the principle but because of poor application. Inadequacy of the examination was mentioned above. A second and frequent fault is failure to apply the information elicited. All too often the findings are merely recorded on a card and filed away. The value of periodic health inventories depends almost wholly upon the soundness and practicability of the advice offered. Individualization of diagnostic procedures and of guidance is essential, particularly in dealing with senescent individuals.

Specifically, periodic health inventories should include consideration of the following possible aids to greater health and enhanced work efficiency: analysis of capacities can reveal the limits of exertion or mental strain beyond which it is unwise to go; discovery of correctable defects in their incipiency makes possible correction before irreparable damage results; early discovery of chronic and progressive disorders, such as diabetes, hypertension, or arthritis, makes possible the institution of medical management to retard the progression of the disease; and it is an opportunity for education in personal hygiene, particularly in such matters as diet, fluid intake, play, adequacy of rest, and emotional conflicts.

Constructive medicine as applied through such periodic consultations is not a panacea which can prevent all ills, nor is it without certain definite and serious limitations. One cannot prevent all disease, any more than safety programs prevent all accidents. Even though a man may be in excellent physical condition, he may still acquire serious and acute illness, such as pneumonia or influenza, or he may meet with a serious accident. But if the individual is in the full bloom of really good health *prior* to the acute infection or accident, his chances of recovery and his speed of recovery are greatly enhanced. One of the fundamental principles of geriatric medicine, which is concerned with the care of the aging, is that in older individuals the outlook in an acute illness is predicated more upon the condition of the patient prior to the acute disorder than upon what treatment is applied. This is just opposite to the situation which applies to illness in youth. The pediatrician has every right to assume that the child was quite healthy prior to an acute illness. The margin of safety gets less and less as we age. Thus constructive medicine, even though it does not prevent all illness, decidedly reduces the total of absenteeism: by shortening the periods of time lost in unavoidable illness; by retarding progressive disorders common in senescence and responsible for frequently recurrent absenteeism; and by actually avoiding certain disorders.

Of perhaps even greater moment are the potentialities of constructive medicine in increasing work efficiency. Improvement of health improves vigor, endurance, and the ability to accomplish. Let us take for example the effects of a mild anemia discovered in the course of a periodic inventory and not associated with any particular complaints on the part of the patient. The consequences of such an anemia can be likened to attempting

to operate an automobile with low grade gasoline as fuel. The car runs, but it does not have the pickup and horsepower that it should and would have if operated with high octane gasoline. Correction of such minor anemias has precisely the same effect upon the work capacity and pleasure in life of individuals who are just slightly below par. For a long time I have wished for the opportunity to measure the productive output of perhaps two hundred workers, before and after the correction of anemias so apparently minor that most physicians ignore them. The range between average (normal) and optimum is considerable. Examples of this nature could be multiplied indefinitely.

The chief limitations of periodic consultations for the improvement of health are the time and cost involved in carrying them out correctly. Yet, if done at all, the inventories *must* be comprehensive and detailed or the procedure will again fall into disrepute because of slipshod, hurried, or routinized application. That time and money so spent are wisely invested has been proven repeatedly.

Partly because of the inevitable expense per unit so serviced, constructive medicine of this type should be applied first to the key men in Industry. The value of these individuals is such that the cost is proportionately negligible. It is wasteful to permit the physically exhausted individual, who is running on his nerve and likely to crack at any moment, to continue in a directive capacity. Just as it is the Flight Surgeon's assigned responsibility to ground pilots when not fit to fly, it should be the responsibility of Industry's medical advisors to "ground" key personnel when unfit to carry on. Furthermore, the application of a thorough physical and mental inventory should start at the top because Labor has always been opposed to periodic examinations. Such is the childishness of mankind that if this be offered to Management and not to Labor, it will not be long before Labor will clamor for it.

For proper application it is essential that the medical inventory be completely confidential. It is impossible to obtain honest and complete histories from individuals who suspect that the record of their examination will be made available to their administrative superior or to anyone else outside of the physician's office. These inventories frequently include much very personal material, and full intimacy between the patient and physician is requisite. The greater the confidence of the patient in the integrity, as well as in the clinical skill, of the physician, the greater the possibility of benefit. Furthermore, the administrative superior or lay personnel officer is in no position to evaluate the significance of the medical findings. It must also be emphasized again that the detection of minor but potentially significant disturbances and early depreciations of reserves requires the highest type of diagnostic acumen. Therefore, it may often be best to arrange periodic consultations outside of the plant medical department and to have merely a report of recommendations returned to the administrative head.

THE UNITY OF SCIENCE IN EDUCATION

By CHARLES I. GLICKSBERG

It requires no extensive documentation to support the thesis that the modern mind has been decisively influenced by the growth and development of science—whether for good or evil is in this connection beside the point. The spread of scientific enlightenment has been going on for centuries; what is novel about our age is the extent to which the scientific outlook has been diffused so that our philosophy of life has been radically transformed. To acknowledge this fact need imply no excessive faith in the potentialities of science. The laws of physics may not be the laws of fate; scientific thought may perhaps be guilty of injecting an unconscious quasi-theological absolutism into its interpretation of the universe; scientific materialism may have its serious limitations as a philosophy. But these criticisms, and many others like them, do not impede the steady advance of science. On the contrary, paradoxical as that may seem, they hasten its progress. For the health of science depends on systematic and rigorous self-criticism. It is more than willing to meet the challenge of competing systems of thought if these can prove the empirical validity of their argument. If they succeed in doing so, they are simply incorporated into the revised body of scientific thought.

But in its reliance on controlled observation, science makes no concession to the apostles of obscurantism. Inherent in the scientific method is a faith in reason which it is clearly the duty of the schools to convey. What is this faith in reason? It has been admirably stated by Alfred North Whitehead in *Science and the Modern World:*

> [It is] the trust that the ultimate nature of things lie together in a harmony which excludes mere arbitrariness. It is the faith that at the base of things we shall not find mere arbitrary mystery. The faith in the order of nature which has made possible the growth of science is a particular example of a deeper faith. This faith cannot be justified by any inductive generalization. It springs from direct inspection of the nature of things as disclosed in our immediate present experience.

If modern education is to be maximally effective, it must strive to implant in the mind of the young the realization that the scientific method has universal, not limited, validity. It is not restricted to the observations or insights of any one group of individuals; it is not confined to "material" things or to specialized subject matter; it embraces within its scope all problems that men must face, all that is given, the mental as well as the physical, the social as well as the narrowly "scientific." It can be, though of course with varying degrees of precision and fruitfulness, applied to all fields of inquiry. Hence educators must throw off the departmentalized frame of mind and form a new and more inclusive perspective which will reveal and help to put into practice the unity of science in the educative process. As Karl Pearson challengingly stated the issue in his *Grammar of Science* about thirty years ago: "The field of science is unlimited; its material is endless, every group of natural phenomena, every phase of social life, every stage of past or present development is material for science." The truth Karl Pearson formulated has not been adequately grasped and its experimental application in the schools has scarcely been attempted.

If the schools have thus far failed miserably in their efforts to train students in scientific habits of thought, the scientist as well as the educator must be held blameworthy. It took the scientist a long time to realize that he could no longer remain "pure." Inevitably the centripetal pull of society draws him into its vortex and forces him to participate in its activity. He can no longer isolate himself on the ground that his work is devoted to "pure" research or to "pure" science. Increasingly he has been compelled to assume social responsibility for the consequences of his experiments, his discoveries, and his teaching. This growing sense of social responsibility is specially marked in the writings of men like Hyman Levy, J. D. Bernal, Lancelot Hogben, J. G. Crowther, John Dewey, and Alfred Korzybski. Nor

is it surprising to find that they emphasize the importance of education as one means of changing the mind of man and eventually transforming social practice.

Unfortunately many scientists are still bogged down in the rut of the traditional distinction between science as method and science as "life." Equally unfortunate is the fact that the public is held captive by the same stereotyped dualism. It is commonly believed that when the scientist puts on his laboratory coat (like a priest donning his sacerdotal vestments) and looks through a microscope, he is behaving scientifically. As soon as he doffs his coat, he reverts to type; that is, he is privileged to think and behave according to other than scientific canons. This is the popular religion of science based on a profound misconception of the function and sphere of scientific thought. It springs from a failure to comprehend the indivisible unity of science. People generally manifest an almost worshipful attitude toward the scientist. They regard him as a holy oracle, a final authority, one who knows all the answers. The modern equivalent of the primitive shaman, he peers into the inner mysteries of Nature, he weighs the sun and measures the parallax of a star, he searches for the cure of cancer, he brings the dead back to life.

By thus erecting science into a virtual religion, people unconsciously but effectually separate it from life—the life they lead from day to day. When there is something wrong with their heart or digestive tract, they immediately consult a doctor; when there is something wrong with the body politic, they will often turn to the demagogue or the dictator for a magical solution. What is even more striking, in matters social, economic, and psychological, regardless of how complex these may be, they believe themselves perfectly qualified to pass judgment. They have no hesitation, for example, in venturing reckless, unsubstantiated opinions on the subject of race, international peace, the treatment of the Germans after they have been conquered, the intrinsic inferiority of the female of the species as compared to the male, the sinfulness of divorce, the nature of intelligence, and the inheritance of acquired characteristics.

The same harmful dichotomy is also evident in the traditional teaching of science. Physics and chemistry and biology and general science are taught primarily for their value as subject matter: so many blocked out chunks of knowledge to be handed out to each student. It is doubtful if there is much of a carry-over from the lessons assigned and taught from the textbook, often by the outmoded lecture or demonstration method, to the problems and perplexities that the students encounter in their everyday life. How could there be when, with few but notable exceptions in some progressive schools, no explicit effort is made to apply scientific knowledge to the vital stuff of experience? In one classroom, the students hear of the "law" of gravity and the "laws" of motion; in the next, they engage in furious but unilluminating debates on the problem of equal rights for women, racial tolerance, war, democracy, Communism, Fascism, and world peace. Any one listening to them "think out" these problems in class will observe the ease and readiness with which they indulge in "phoney" catchwords, the uncritical aggressiveness with which they make statements unsupported by a shred of evidence, the ardor with which they voice beliefs that have no empirical foundation. They use symbols which point to no clearly given occurrent because they are driven primarily by the desire to dominate, the will to win the argument. There has apparently been no transfer value in the scientific instruction they have received. Not that the science teacher is alone to blame. Every teacher must bear his share of the guilt. The science teacher tries to do a conscientious job, but his method of approach is wrong. The uncritical thinking of the students we turn out is a sufficient indictment of our educational system as it functions at present. The gap between science as theory and science as conduct, science as "laws" in textbooks and science as living thought applied to all human problems, has not been bridged, and the gap yawns widest in our schools.

The relationship between democracy and a genuinely scientific education is closer and more important than we commonly realize. In a democratic state, no distinction is drawn politically between those who use their intelligence critically and those who fail to do so,

between those who utilize their knowledge constructively in order to improve themselves and to contribute their maximal share to the progress of society and those who walk in darkness. The vote of the ignorant hillbilly counts as much in electing a man to Congress as that of the professor of sociology at the State University. Yet all these people are the concern of the educator. A democracy must endeavor, by means of its educational resources, to combat the influence of unscientific thought and action. It must furnish a basic scientific education to all people so that they may be better informed, more discerning in their judgment of affairs, more intelligent and discriminating in their actions. Since the educational goal should be to make scientific thinking function in all areas of living, all teachers have a responsible role to play in improving the power of the young to think critically. It is essential that they be taught in a way to make scientific habits of thought habitual and enduring.

This is but another way of saying that departmentalized instruction, which attempts to feed students knowledge regardless of their interests or needs, is ineffectual. Nothing is more potent in one's own education than his factually-founded realization of the inexorable nature of scientific occurrences. The laws of science give him true freedom; he can depend on them as he can on nothing else in this precarious universe.

It is in the schools that the battle of science will be fought—and lost or won. Despite all the magnificent progress being made in the field of war technology, the net result, so far as its effect on the thought and behavior of the masses of men and the management of society is concerned, is negligible, and will probably continue to be negligible unless education specifically takes over the task. Either science is useful and valid in solving our crucial human and social problems or else it is but a specialized discipline applicable within certain circumscribed areas of experience but not relevant to the total complexity of human life on this spinning planet. If we adopt the former alternative, then we shall not agree with those thinkers who argue that science is, by definition, cut off from the realm of values. It is, they maintain, descriptive, not normative. It tells us *how* things happen; it can cast no light on *why* they happen. Here we reach to the root of the philosophical problem, the heart of science. The solution we give to this problem will determine in large measure the kind of scientific education we provide for the young. What ultimate purpose life on earth serves, no one knows, and it does not appear likely that we shall ever find out. How the universe may appear to a creature endowed with a different sensory apparatus, finer, more complexly differentiated than ours, is beyond our scope of knowledge. Even at the risk of tautology we must repeat: we can know only that which we can know. The rest is silence. Our brain, our senses, our perceptions, our reason, these working organismically furnish us with the material out of which public knowledge is born, and this empirico-rational knowledge is our sole reliable means of mastering our environment and of controlling our life, individually and collectively. There are those who profess to have access to supernatural or intuitive sources of knowledge, but since there is no way of empirically confirming that which they know, their "knowledge" must be rejected out of hand as not belonging within the scientific canon of tested knowledge.

If this thesis be accepted, then it logically follows that scientific habits of thought, like socially acceptable behavior, are the province not of one department but of the school as a whole. It is the basis and superstructure, the seed and flower, the crown and consummation of the educative process. Hence it is the function—nay, the bounden duty—of every teacher, though with varying degrees of thoroughness and skill, to train and develop the young in the "art" of scientific thinking. Teachers of all subjects should not only be scientifically literate; they should welcome every opportunity of cooperating with science teachers so that the ultimate aims of education may be most efficiently and fruitfully achieved. Teachers of English, for example, are dedicated to the task of bringing beauty into the life of students, but there is no convincing reason why the quest for beauty should not be strengthened and supplemented by the quest

for truth. The two are not, as is commonly believed, in conflict.

Once the departmental barriers are broken down and the bigotry and provincialism that are the product of departmentalization have been dissipated, it should be relatively easy to devise ways and means of putting into practice the ideal described above. The English teacher, to use him again as an example, has at his disposal a rich variety of material from which to choose, though there is no teacher, no matter what his subject, who cannot play his part in the attack on prejudice, muddled thinking, lazy intellectual habits—the idols of the market place. Discussions alone will not remove deep-seated emotional prejudices or extirpate the roots of bias, but they can throw light on dark places and gradually compel students, still open to the voice of reason, to re-examine the basis for their hasty yet cocksure assumptions.

In addition to the teaching of subjects like physics and chemistry, it is essential that the young receive thorough training in the science of "human nature." Such a course, which is fundamental to practically every part of the curriculum, would be as comprehensive in scope and detailed in procedure as the interests and abilities of the students permit. Like all those who have no professional scientific knowledge or training, what the young are primarily concerned about is how human nature functions, why we behave as we do, the secret of the mind and body and their interaction. What they seek is not only information about stimulus-and-response, conditioning, heredity, the influence of environment, and so on, but also insight into the way scientific methods of control can "change" and "improve" human nature. It is scarcely an exaggeration to say that if we could arrive at an objective and empirically tested agreement on the nature of what we call "human nature," half the controversies that now rage in the field of politics, sociology, economics, and philosophy would automatically end.

To be successful, such a course would have to deal with problems that challenge the interest of the young. History teachers, English teachers, and science teachers could join forces in helping students to undertake simple research in some such problems as: What is intelligence? Is there a close correlation between intelligence and race? Is character the result of heredity and environment, or both, and in what proportions? What characteristics are inherited and what acquired? Why do many people act irrationally? How does the human mind work? What is hypnotism? Are people highly suggestible? How is this used by business and political interests to influence the minds of men? Is mental telepathy scientifically confirmed? Is it possible to foretell the future? Many of these problems no doubt will prove highly difficult, perhaps insoluble, but it is a profitable experience for the young to tackle them even if in the end they feel baffled. For that is a good way of putting the scientific method actually to work and testing its range of operational validity. Once the student comprehends how the scientific method is applied, he will discover in the course of his investigations the difference between relatively certain truths and those truths which possess only a weighted measure of probability. All the facts can never be gathered. Hypotheses are not absolutely certain. That is the best we can attain in this contingent and hazardous universe where risks must always be taken. Even facts are elusive, subject to change and correction. When incontestable evidence is lacking, however, there is no reason for falling back on childhood faith or wishful thinking. Students are under a moral obligation, whatever the problem they are exploring, to weigh all the available evidence and arrive at the best possible conclusions under the circumstances.

Recently there have been published books which are within the range of comprehension of high-school students. *Life and Growth*, by Alice V. Keliher, one of the volumes issued by the Commission on Human Relations, is interestingly written, easy to understand, and challenging in content. Also excellent as an introduction to scientific thinking is Paul Grabbe's *We Call It Human Nature*, with cartoons illustrating the fundamental subject matter of psychology and textual material describing the basis for psychological insight into the complexities of human nature. Students interested in the study of

superstitions should read *Do You Believe It?*, by Otis W. Caldwell and Gerhard E. Lundeen, and then proceed to gather field material from their own communities.

No doubt there will be science teachers who will look disparagingly upon this curricular innovation as but another step in the direction of popularizing and vulgarizing science. Diluting scientific knowledge, dramatizing it so that it will hold the interest and penetrate the intelligence of the average adolescent is in their eyes a form of treason. But they are mistaken. The issue is one between effective teaching that leaves its indelible stamp on thought and conduct, and ineffective teaching, knowledge that remains theoretical, abstract, unassimilated. The traditional science course in high schools leaves those students who have neither the opportunity nor the ability to enter college with an utterly inadequate conception of the scientific method and outlook in our society. Even if in their class they were told of the enormous importance of science in our civilization, the breach between theory and practice, science and life, would still not be closed. If science is to be more than an honored part of the curriculum, if it is to be more than a quantitative inculcation of subject matter, if it is to permeate the personality and condition the mind of the student so that he will think more critically and behave more rationally, then it must be taught as such. All science teaching, particularly on the secondary school level, must be "impure," applied, humanly practical and significant. It should be concerned not only with machines, amperes, atoms, motion, light, heat, electricity, and chemical formulas; its scope is the entire universe, all of human life.

It includes such unorthodox and relatively unexplored subjects as economics, politics, human nature, love, hate, war, dreams, myths, religions, attitudes, opinions, beliefs, values, truths. All these fall within the spacious province of science. What differentiates them from "science" proper, in the conventional sense of the term, is that the degree of probable truth to which we can attain in the social and psychological sciences is less precise than what we can hope to achieve in the physical sciences, but the scientific method of attacking a problem and arriving at provisional truths remains unchanged. If the obscurely given is to be known, it can be known only through the aid of the clearly given, that which is already known. If science is to justify itself and prove socially useful, it must break down the artificial barriers, departmental and falsely humanistic, erected with the design of limiting its function and scope. Everything points at present to the imperative need for a drastic revaluation of educational objectives. As John Dewey summed up the matter in 1933:

> The obligation incumbent upon science can not be met until its representatives cease to be content with having a multiplicity of courses in various sciences represented in the schools, and devote even more energy than was spent in getting a place for science in the curriculum, to seeing to it that the sciences which are taught are themselves more concerned about creating a certain mental attitude than they are about purveying a fixed body of information or about preparing a small number of persons for the further specialized pursuit of some particular science.

TREES OF SOUTH FLORIDA

I. FIVE NATURALIZED EXOTIC FOREST TREES

By JOHN C. GIFFORD

When Florida's winter visitors think of trees, they probably visualize her palms, not knowing, or forgetting, that other unusual and useful exotic and native trees grow in South Florida. It is the purpose of this article to call attention to ten kinds of trees that could be grown profitably on many thousands of acres now idle.

The Candlenut Tree

The candlenut tree (*Aleurites moluccana*) is a near relative of the better-known tung tree (*Aleurites fordii*), which has been planted in the Gulf States to furnish a domestic source of tung oil. Candlenut oil is also a valuable drying oil, which is acknowledged to be as good as the best grade of linseed oil and with proper treatment serves well for several of the purposes for which tung oil is used. It is strange, indeed, that the candlenut, which grows so luxuriantly and fruits so freely in South Florida and the West Indies should be neglected, because the tung tree, not as good silviculturally in the United States, produces a somewhat better oil. Since the supply of tung oil from the Orient has been cut off by war, it would seem wise to develop all sources of drying oils, not only tung oil in the Gulf States and oiticica oil in Brazil, but also candlenut oil in Florida.

In contrast to the tung tree, which is a deciduous tree of temperate climates and grows relatively slowly, the candlenut tree grows with great rapidity in South Florida, producing an enormous crop in less than ten

A CANDLENUT TREE

IT IS SO LOADED WITH FRUIT THAT THE LIMBS ARE BENT BY THE WEIGHT OF THE LARGE NUTS.

years, during which period many trees will become a foot in diameter. Whereas the tung tree requires good agricultural land and much attention to cultivation and fertilization, the candlenut can be grown as a forest crop on the inexpensive, rocky limestone land of South Florida.

The natives of the South Sea Islands string the nuts on a stick and use them in place of candles—hence the name. The candlenut is a common tree in the Hawaiian Islands, where it is called *kukui* by the natives, who have long extracted and used the oil from its nuts.

Three additional tropical species of *Aleurites* are *trisperma*, *cordata*, and *montana*. The word *Aleurites* means flour in Greek and was chosen for the genus because the young leaves look as if they had been covered with meal. The nut of *A. trisperma*, the mu-oil tree, is soft and not difficult to press, but the few trees of this species in South Florida, although fruitful, are not very thrifty.

The Sapodilla

Industry in Yucatán is devoted mainly to archaeology and chewing gum. The latter is the gum of the sapodilla tree. In addition, this tree yields a wholesome fruit, which, Barrett says, is equal to a good pear sprinkled with spices and flavored with maple sugar. The fruit resembles rusty-coated apples. When green, it is full of sticky gum which soon ripens into a sweet, palatable juice. The Conch of the Florida Keys talks feelingly of his "sours and dillies." By sours he means limes; by dillies the sapodillas, sapodilla being the Spanish for little *sapote*.

The great home of the sapodilla is the Yucatán Peninsula. The ancient Mayas used its wood for timbers in their buildings, and it has lasted for centuries, being more durable than metal. They are said also to have chewed its gum. The present gum gatherers cut the trunk of the tree with a machete in V-shaped gashes. The milk flows into a hole at the foot of the tree, or on broad leaves or a canvas sack. The trees are allowed to rest from four to seven years, but now and then a large number die. The principles of forestry are beginning to be applied to growing sapodilla in British Honduras where, it is hoped, "supplies from fully stocked crops of sapodilla established by silvicultural methods will supersede the gum derived from the wild collecting industry." I could never understand why the gummy milk could not be squeezed out of the green fruits and thus obviate the necessity of mutilating the tree to death.

The sapodilla has been growing in South Florida, especially on the Keys, for many years. It was probably introduced here from the West Indies or Central America. Some assert that it is native, but it is probably a naturalized species.

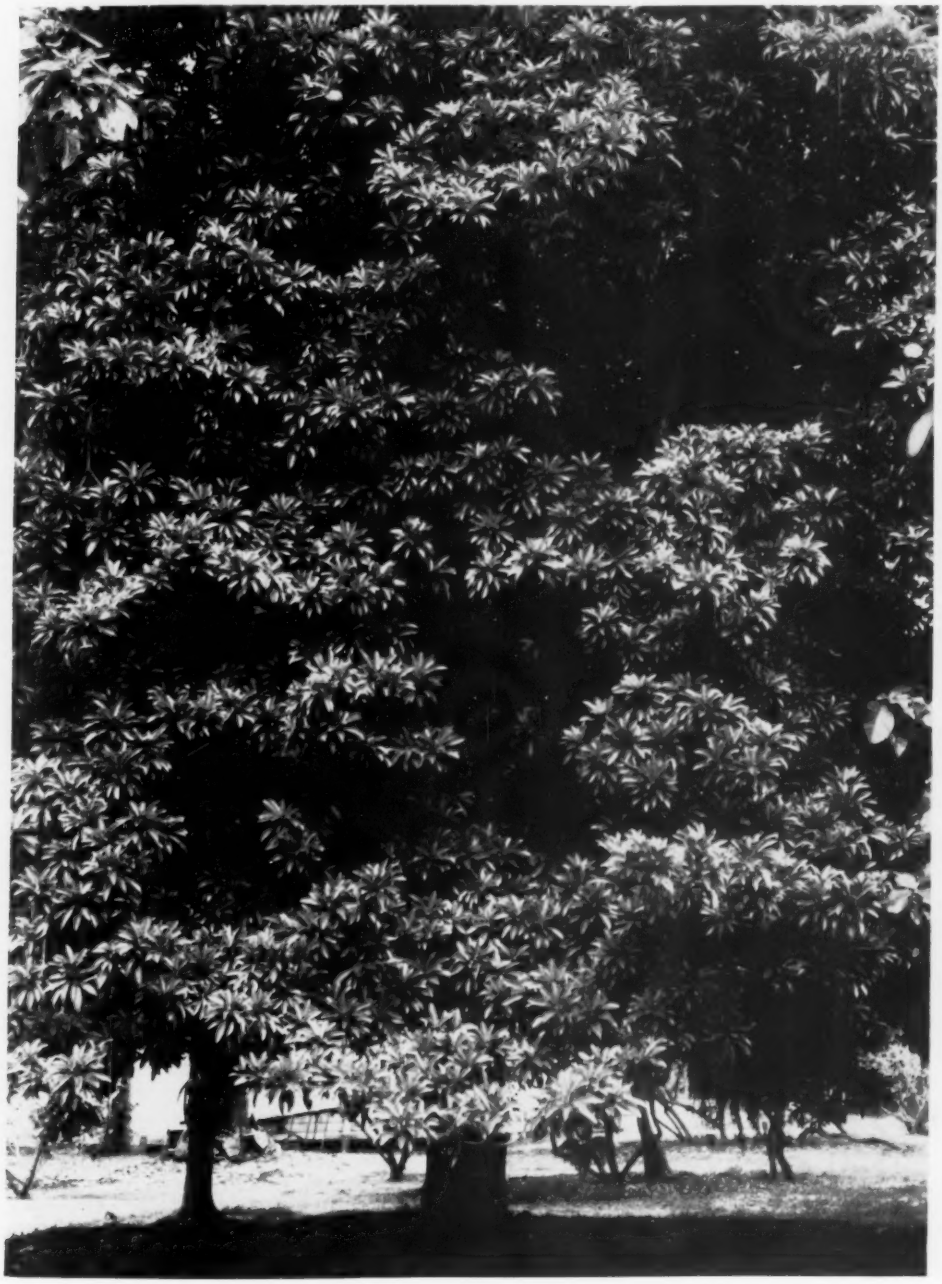
The Lebbek Tree

The scientific name of the lebbek, or siris, tree is *Albizzia lebbek*. A sister of this tree, *Albizzia julibrissin*, is common in the South as far north as Washington. Albizzi, for whom the tree was named, was an Italian nobleman, who was among the first to plant seeds of this tree in Italy. The specific name *lebbek* is, perhaps, of Arabic origin. My first interest in the tree began by reading David Fairchild's Circular No. 23, Division of Botany, U. S. Dept. of Agriculture, in 1900. He says, "The sapwood is white and heartwood hard, brown, mottled with darker longitudinal streaks. The wood seasons and works well and is durable." He notes that hundreds of thousands of these trees were planted in Egypt in 1809. He says further that it is "as easily transplanted and propagated by cuttings as a willow. Large trees can be dug up, severely pruned back and set out with very little risk of their dying." At that time (1900) both seeds and cuttings were distributed by the United States Department of Agriculture. Some trees might have been introduced into Florida before that time, because the lebbek has been in the Bahamas a long while. I think it was there that it got the name of "Woman's Tongue," because of the rustling of its dry pods in the wind. Some students in the University of North Carolina who were working on this tree told me they found so much soluble starch in its wood that they nicknamed it the "potato tree."

When the trees are full of pods, as they are every year, the noise is bothersome. The enormous amount of seed shed by the lebbek insures its extension. It is a very

vigorous grower. A single tree is soon surrounded by a dense thicket of hundreds of little trees. It sheds a rich litter over the surface of the land. I have grown young lebbek trees in pots, and in the mat of fine roots close to the porous clay there are usually hundreds of white masses of nitrogen-fixing bacteria.

Considering the ease of propagation, the rapidity of growth, and the character of its



LARGEST SAPODILLA TREE FOUND BY THE AUTHOR IN SOUTH FLORIDA

THIS TREE IS LOCATED ON THE BLACK PLACE AT SNAPPER CREEK. IT BEARS THE LARGEST FRUITS OF ITS KIND THE AUTHOR HAS EVER SEEN: THEY ARE WHITE AND SOMETIMES 4 INCHES IN DIAMETER.

wood, it seems to be the ideal tree for which the paper manufacturer is hunting.

Many people have assumed that the wood is inferior in quality, but this is a mistake. According to Herbert Stone in his *Timbers of Commerce*, it is known in England as East Indian Walnut. It has various names in the Indian dialects, and India and adjacent parts of southeastern Asia appear to be its home. The wood weighs, when dry, from forty-one to fifty-six pounds to the cubic foot. In hardness it is comparable to English ash and although it has a rather coarse and open grain, the surface is lustrous and silky when finished. Stone says that in India it is used for sugar-cane crushers, oil mills, furniture, well curbs, wheelwork, and in South India for boats. The heartwood is a dark brown walnut color. There is usually a thick band of white sapwood; and young trees are usually all sapwood, which gives rise to the mistaken idea that the wood is soft and not of much value. The fact, however, that it is used in so many ways in India indicates that we are overlooking a good timber tree.

There are several trees, like the famous saman of Cuba or guango of Jamaica, and guanacaste in Central and South America, that are similar to lebbek. All of these produce a hardwood with the general appearance of walnut for which they are sometimes substituted.

Brown, in his *Sylviculture in the Tropics*, says that the fine avenues of lebbek in Cairo were killed in 1910 by aphids. So far, in Florida, this tree seems safe from insect attack and disease. In India it has the reputation of being able to take care of itself. It is a tree that truly roots for a living. In the *Indian Forester*, G. M. Ryan says that root suckers of *Albizzia lebbek* have been found a distance of one hundred feet from the parent tree.

A constant cover of pine trees subject to frequent burnings, according to the best authorities, exhausts the soil. It is therefore imperative that, wherever possible, we use these leguminous trees for soil betterment.

The cultivation of several crops is impossible in the tropics without shelter trees, and

THE LEBBEK AS A SHADE TREE

THE LIGHT PATCHES AMONG THE LEAVES ARE POMPONS OF BLOOM, GREENISH-YELLOW IN COLOR.

CASUARINAS LINE A MIAMI SHORE

THESE TREES, GROWN FROM WIND-SOWN SEED ON AN OLD SPILLBANK, ARE ABOUT FIVE YEARS OLD.

the trees usually chosen belong to the bean family. These not only prevent erosion and afford shade to the ground, but also add to its fertility. The lebbek has been used to some extent for this purpose.

Lebbek is a tropical tree, but it can stand a lot of dry weather and was not injured by cold in South Florida in our last cold spell. Since it does so well in northern Egypt, it will probably grow in the central part of Florida. It flourishes on the rough, rocky land of South Florida. Its seed is most likely to germinate in crevices of the rock containing some humus. Whether we plant it or not, it is pushing ahead of its own accord, and in many places in the Redlands section the scaly-bark casuarina and the lebbek together are now very common. They may be the forerunners of the forest of the future in South Florida.

The lebbek bears flowers in pompon-like masses, greenish-yellow in color, and with a pleasant fragrance, whereas *Albizzia julibrissin*, common as an ornamental tree throughout the southeastern states, bears great masses of pink flowers in June.

The leaves of the lebbek are shed in the spring. At that time the great masses of papery pods are exposed and, although not decorative, are so unusual as to attract much attention. Were it not for the rustling noise and litter of pods, it would be far more popular as a shade tree. It is much used anyway because of its vigorous growth and comforting shade throughout the major portion of the year. According to O. F. Cook in his "Shade in Coffee Culture" (Bulletin No. 25, Division of Botany, U. S. Dept. of Agriculture) it is used for shade in coffee culture in the French West Indies where it is called *bois à friture* and *bois noir*. Its great value for fertility is shown in the analysis by M. Grandeau: 1000 kilograms of dry leaves contains nitrogen, 18.79 kilograms; phosphoric acid, 1.40; potash, 3.18; lime, 37.00; magnesia, 2.50. Cook also says that from the trunk a gum similar to gumarabic is obtained; also that the wood is hard, close-grained, veined with pink and red, darkening with age.

Casuarinas

Although natives of faraway Australia and the South Seas, these trees encircle the tropics of the globe. For binding shifting sand on the shores of the sea in windy situations, they have few, if any, equals. They may be trimmed into a windbreak hedge to such a height that homes in its lee will be protected in times of severe storms.

Casuarinas are called she-oak in some places and Australian pine in others but they are neither pine nor oak, although their wood resembles that of oak and in general appearance they are not unlike pines. These

CAJEPUTS AT CHAPMAN FIELD
AMONG THE MOST POPULAR TREES FOR SHADE AND ORNAMENTATION IN SOUTHERN FLORIDA.

trees are also called whistling pine, Polynesian ironwood, beefwood and a host of other native names, but its scientific name, *Casuarina*, is not difficult and is appropriate since it means "with branchlets like the feathers of the cassowary bird." The branchlets are green, pendant, and without noticeable leaves. These trees are favorites of the natives of all sandy tropical shores and are highly praised by almost every forester in tropical regions.

There are many old casuarinas in South Florida. On the seashore of Biscayne Bay, not far from Homestead, there was a group of them called "The Cedars." For sailors these striking trees formed a landmark that was conspicuous for a long distance. They were the leftovers of an old nursery which had obtained the seed from Cuba.

Casuarinas grow on salt marsh, seashore sand, and rock and muck at the rate of ten feet or more a year under favorable conditions and they naturally grow straight into the air. They are long-lived and may reach a height of one hundred and fifty feet. Being gross feeders, they have a very extensive and sturdy root system. To uproot a stump two feet in diameter is a real job for both man and dynamite. They fruit abundantly while very young and are easily propagated from seed. They are easily injured by fire and cold, but are remarkably free from disease.

The common species is *equisetifolia*, meaning "with jointed leaves like horsetails." There is another species in the Redlands region. I am not sure who first introduced it and am not sure of its specific name, but think it is *C. lepidophloia*. It is a beautiful tree, especially adapted to a rocky limestone soil and characterized by the production of many shoots from its roots. It soon produces a thick barricade and can be easily and quickly propagated from these root suckers. This species is rapidly spreading throughout this region because many people like it better than the common original kind. I believe that this species is dioecious and that we have only the male kind, for our trees produce no seed.

From a botanical standpoint the inflorescence of *Casuarina* is puzzling. The process of fertilization is primitive. The seeds form in a small cone and are released when the ripe fruit is dried in the sun. Its nearest relatives are the willows and walnuts.

The wood of casuarinas is pink, turning dark with age. It is heavy, hard, and strong and is excellent for fuel and scaffold poles. It produces an enormous amount of wood in a very short time on soils where few other trees will flourish. Like many other tropical woods, it is seasoned with difficulty. The trees should be sawn as soon as cut and then carefully piled in a ventilated, shaded place. Small straight poles of *Casuarina* could be quickly grown for various purposes; even, it is said, for paper. This wood is used for war clubs by the natives of the South Seas.

C. equisetifolia appears to do as well here as anywhere in the tropics. This tree seems very much at home on the Keys and for many years has been a favorite as a shade tree in Key West. Although not a native, this tree may be classed as a naturalized immigrant and is so listed by several botanists.

The Redland species (*lepidophloia*), with many little ones springing from the roots of the mother tree, naturally forms a group capable of withstanding the severest gales

Wind hitting such an incline is diverted upward, forming a protected area of large extent in its lee. When growing in group form, the trunks are protected from the scorching and drying effects of the summer sun.

These casuarinas may form a very welcome mantle of green if our native Caribbean pine becomes a thing of the past, owing to excessive cutting for lumber and fuel. Thus man, with the help of wind and fire over a period of many generations, slowly changes the face of nature.

The Cajeput

The first mention of the cajeput as growing in America was, I think, in an article by me in the February, 1910, issue of *American Forestry*. The following is quoted from that article, "Camphor and Cajeput":

> The cajeput (*Melaleuca leucadendron*) is full of promise for the low, moist regions of the southernmost part of the state of Florida. Like the Australian pine, it withstands saltwater overflow. The growth of the cajeput on land subject to overflow along the shore of Biscayne Bay has been so rapid that its adaptability to such situations cannot be questioned.
>
> My trees are now twelve to eighteen feet in height and I received the seeds in a letter from Dr. Maiden of Sydney, Australia, about three years ago. [That was in 1906.] They are already blooming profusely and yielding an abundance of seed. The flowers are at times covered with honey bees. It is, therefore, probably a great honey-yielder.

CAJEPUT IN THE EVERGLADES
THE CAJEPUT IS A NATURAL SWAMP TREE THAT GROWS IN BOTH FRESH AND BRACKISH WATER.

SEEDPODS OF THE CAJEPUT
WOODY CAPSULES ARE FILLED WITH SEEDS AS FINE AS DUST AND EASILY GERMINATED.

This same tree was introduced a few years later on the West Coast of Florida by A. H. Andrews of Estero. Since that time it has spread naturally in the Everglade region and should now be classed as a naturalized species. It is one of the most popular trees for shade and ornamentation at Miami Beach and other similar places. The leaves yield a valuable oil. The wood is heavy, hard, durable, and light brown in color. The profuse masses of white flowers yield an abundance of nectar. The bark is thick, punky, and excellent for insulating purposes. What recommends it to many is the beauty of its straight, white stem, and masses of delicate foliage. It grows with great rapidity and while very young produces very small seeds in hard, woody capsules the size of small peas. It is not destroyed by fire because of the thickness of its corky bark. It is a natural swamp tree in both fresh and brackish water. It withstands strong winds. From a silvicultural point of view it has few, if any, equals in the plant world.

Its seeds can be scattered from a saltcellar

over the surface of the water. Nature does the rest. We had trouble trying to germinate these little seeds in soil in the usual way. Little did we suspect that all we needed to do was to scatter them over the water and mud of the swamps and that in time they would actually spread into the wild cypress swamps and hold their own against native trees. The cajeput is being introduced into the Bahamas where it will find a congenial home around brackish lakes or in deposits of muck.

The scientific name of the cajeput is *Melaleuca leucodendron*. *Melas* means black, *leukos* white, and *dendron* tree. It is called black-white tree because in its native land, owing to bush fires, the lower part of the trunk is black. The word cajeput, sometimes written cajaput or cajuput, comes from a Malay word meaning "white tree," for it has a bark that is usually very white and papery, like the northern birch. Its long withes, somewhat similar to the olive, are excellent for garlands. The leaves have a fragrant odor arising from the oil which they contain.

Cajeput oil is distilled from the leaves. It is a slight irritant externally, but less so than turpentine. It gives a sense of warmth internally and causes an accelerated pulse. It is said to have medicinal properties. The main supply of cajeput oil came from New Caledonia via Marseille, France. Like many other products of tropical plants, it could be produced in South Florida and nearby islands.

A few seeds in a letter from far-off Australia, a few trees started, and finally there is a changed landscape. No one can predict what he will do when he drops a seed from foreign parts in a new environment. If it happens to be a weed, he may regret it, but if it is an ornamental and useful tree, he has done well for himself and posterity, especially if, as in this case, it meets with popular approval.

(To be concluded)

GARDEN ISLANDS OF THE GREAT EAST

From now until the boat returned to Java, our trip resembled an enchanted cruise. During the next twenty days we made eighteen stops at islands varying from a few square miles in size to the immense terrain of New Guinea. At each place we met different types of natives who had grown up on their respective islands knowing nothing of the world beyond the waves breaking on their white beaches. These people spoke different dialects, or different languages, came of different racial stocks, and had their own individual civilization. These islands of the Malay Archipelago form a group so unique that I have always longed to return there. I would have been extremely unhappy when we sailed away had I realized I should never see them again. [But Dr. Fairchild did see them again after all (see the review of *Garden Islands of the Great East* on page 77 of this issue)].

* * *

I was unable to go ashore at several of the islands for I came down with an attack of malaria. One servant, Pandok, insisted on rubbing me with cajeput oil—the first time I had ever heard the word. I little dreamed that the oil came from the leaves of a tree (*Melaleuca leucadendron*) which I would later help John Gifford to disseminate throughout South Florida and which would naturalize itself there until today thousands of cajeputs are growing wild in addition to the thousands planted in gardens as ornamentals.—From *The World Was My Garden* by David Fairchild. Quoted by permission of the publishers, Charles Scribner's Sons.

SCHOOL OF PAN AMERICAN AGRICULTURE

By CHARLES MORROW WILSON

ARNULFO MERCADO, a farm boy from remote San Marcos, Honduras, was leaving home for the first time, with good and sufficient reason. He was going away to school.

The time was right, since the Mercado corn and beans were harvested, the millet was threshed, and the peppers were drying on the red tile roofs. Arnulfo, who is 19, weighs 200 pounds, and stands almost six feet, was eager for the journey which would lead him towards what is called higher education.

The latter is not ordinarily available in rural Honduras, or indeed in tens of thousands of rural communities throughout Latin America. Usually, beyond the capitals and other principal cities of the other Americas "college" and "university" are little more than attractive words. As an over-all average in terms of U. S. public school establishments, the common schools of nonurban Latin America provide the approximate equivalent of the first four elementary grades.

About seven years ago Arnulfo was graduated from his local grade school where he studied hard, learned easily, and viewed any additional schooling as a pleasantly whimsical pipedream. Resolved to do his best with the means at hand, Arnulfo went to work on his father's little farm. One day recently the mayor rode out to the Mercado home bringing word that Arnulfo had been chosen to study agriculture in a new school which is being built in the high, lush valley of Honduras' Yeguare River.

Enormously happy, Arnulfo put on his Sunday suit, traded embraces with his mother and father and younger brothers, and walked to the village to share thanks with the local padre. Then he asked Alfredo, his next younger brother, to ride with him, and lead home the horses.

Accordingly, the Mercado brothers rode through a hundred miles of jungles and over the many thorn-bush hills that separated Arnulfo from the interesting abstraction called the higher education in agriculture. It required three hard days of riding to reach the Hacienda Zamorano at the crossing of the respective roads to Danlí and Guinope, some thirty miles below Tegucigalpa, Honduras' unique mountain capital.

Many new buildings are rising on the site of the once-famous hacienda; all built in colonial Honduran architecture—with granite and stuccoed walls, red tile roofs, and handsome hand-carved wooden doors. The Mercado brothers looked down at this place for the higher education and watched other youths strolling curiously about the grounds;

ADMINISTRATION BUILDING OF THE ESCUELA AGRICOLA PANAMERICANA

youths who had come by muleback, or slow train, or roaring plane from Mexico and all the six republics of Central America.

Then the Mercado brothers parted, shaking hands in the manner of mature men. Alfredo, 17, set out for San Marcos, riding his own horse and leading Arnulfo's.

Being afoot, Arnulfo walked to the new campus. An instructor, newly arrived from Costa Rica, greeted the new arrival and saw him equipped with the school's uniform, which consists of denim breeches and work shirt, sturdy brogan shoes, plain underwear and socks, a farmer-style straw hat, and (for Sunday wear only) an attractive white linen suit. Then the instructor explained: "At this Escuela Agricola Panamericana you will be one of a family of young men from many nations of the Americas. All come to the school to work and learn and to carry home to their own farms or communities the good of what they have learned. You do not need money here. This school provides all your needs, including doctor, dentist, and barber. The boys with whom you will work and play are of your own kind; farm raised, good character, intelligent—young men who will make good use of their work and study at this school. They are over sixteen and under twenty-one; for the most part the sons of farmers and tradesmen. Their blood is principally Indian. Of our first seventy-three scholars at least sixty are part Indian. None is rich; none is unfriendly to work."

Arnulfo found the courage to confide: "I am not a scholar, Señor. I've had only a few terms of schooling."

The instructor showed no particular concern. "Here no student is required to have more schooling than his home countryside affords." Arnulfo continued, "I have never had the chance to learn English, Señor." The instructor said: "You will learn to speak and write English well; also, you will learn to speak and write Spanish better. You will learn these two American languages in the company of many other Americans."

The instructors called together a group of the newly arrived scholars—Mexican, Salvadorean, Guatemalan, Costa Rican, Nicaraguan, Panamanian, and Honduran, and be-

BEGINNING OF BUILDINGS FOR THE ESCUELA AGRICOLA PANAMERICANA

A TYPICAL FACULTY RESIDENCE

gan to show them over the far-spreading campus. The grounds cover 3,500 acres—about 5½ square miles—and include forested mountainsides a mile high, along with hundreds of acres in fertile valley fields. The average altitude is about 2,600 feet; high enough to grow many northern cereals, vegetables, and deciduous fruits, but warm enough for most important crops of the true tropics. Arnulfo noticed that several hundred native workmen are busy building the far-spreading college; that men and oxen take ponderous cartloads of volcanic rock from a nearby quarry; that other work crews are felling native white pine and sawing it to timber; that still others are molding and kilning red brick and tiles from local clays. Four faculty residences and a staff dormitory are already completed, and of the four stone dormitories for students, the first is completed and occupied. The "gran" building, also of stone and tile, early Honduran style, is big and imposing and climaxed by a splendid sixty-foot tower. The expansive campus is also marked for games—baseball, track, football and basketball, and a boxing ring. This school of Pan American agriculture will be opened formally on Columbus Day, 1944. But in response to the urgent need for such a school and an avalanche of applications for fellowships, the first entering class was accepted in 1943.

The instructor also pointed out the newly built animal sheds and barns and the cold storage house, and beyond them the lines of gardens and experiment fields. "Some of the crops have grown well even this first year. But some have turned out poorly. . . ."

An Indian youth from Nicaragua suggested, "Maybe not all the planting was made at the right time of the moon. . . ."

The instructor smiled and nodded: "Yes, and perhaps there are other reasons which you and I must study and find out." He pointed. "There to the right you see some fine melons. Down the bend there are several hills of cucumbers. Something went wrong with them. The leaves have curled and the stems have rotted away. . . ." The instructor added, "We are here to study and learn for ourselves, Señores, not merely to quote what others have said."

Next day, September 1, 1943, was the first day of school. At five A.M., while the mesas

BUILDING A MILK SHED

were still inky black, a gong sounded and the students began to emerge from the dormitory. Arnulfo had been impressed by the fact that the dormitories are successions of rooms instead of open barracks. Promptly at six the gong (made from an ancient church bell) sounded breakfast, a plentiful fare of fried beans, white cheese, scrambled eggs, bread, fresh butter, and all the coffee and milk that the hungry youths wanted. After breakfast the students were assembled and divided into groups—about twenty-five to the group, for "practica," wherein each crew is given a month's assignment, one to work in the gardens, another in the dairy barns and horse corrals, another at field tillage, and so on.

After a month of each type of work, each crew is moved to another assignment; each student spending four hours of each week day at practical and well-supervised farm work. When the first morning's work was finished (it was punctuated by much explanation and discussion), all crews returned at eleven for lunch, which is served in a handsome stone mess hall. Again the scholars were hungry, and again the food proved satisfying; thick soup, boiled beef, white potatoes, green vegetables from the school's extensive gardens, crisp tortillas instead of bread, and plenty of oranges.

After lunch come three hours in classes. The beginning course includes an hour's class in English, an hour of mathematics, and an hour of elementary science—chemistry, physics, geology, and botany, with accent on valid training in basic scientific principles.

When the classes were finished at four, the students joined in their first recreation period—two hours of whatever sport they select. Arnulfo chose baseball and played with all his might until the supper gong sounded at six. Again he was hungry, and again he ate plentifully of beef, beans, tortillas, cabbage, and milk. After supper comes the "visiting period" in the recreation hall and due opportunity to listen to the radio or write letters or play cards or checkers, and once weekly to see a motion picture. Then comes the study hour, in the student quarters. Lights go out promptly at nine.

That was a typical day at Escuela Agricola Panamericana, a free work-and-learn school for boys of the American tropics; a school course which lasts three years, with a fourth or specialization year for students who show outstanding promise. The school is apace with the Central American tradition for a poor man's self-made leadership. Its graduates are urged to and are prepared to return to their own countrysides or farms, or to qualify themselves for helping their respective governments along lines of agricultural extension work or otherwise improving the indigenous agricultures of the American tropics.

The School of Pan American Agriculture has been established by the United Fruit Company with initial grants totalling $800,000. Early in 1942 the National Congress of Honduras authorized the location of the school within its boundaries, and lands and building sites for the unique college were purchased with the initial donation. When completed, the physical plant will cost upwards of $1,000,000. Paying the entire sum, the United Fruit Company pledges the permanent maintenance of the school, which will endure exactly so long as the company endures.

Physical properties of the school include

BULL PEN FOR OUTSIDE FEEDING

VIEW OF THE SCHOOL'S FIRST VEGETABLE GARDENS

a horticultural section, with nurseries, orchards, and vegetable gardens; and a livestock section, equipped with dairy barns, stables, pig sties, chicken houses, and refrigeration and creamery buildings. The school's forest lands extend westward into the mountains. Down the valley are the experimental fields and pastures, the former being planted with corn, beans, rice, potatoes, and other annual crops. The range is being developed as model livestock pastures. The school supplies its students with all necessary books, laboratory equipment, tools, and other supplies—without cost to the student. In fact no student pays a penny or centavo for his schooling. And no student is exempted from work.

The curriculum is carefully geared to the practical agrarian leadership of the American tropics. Besides the first year of English, general science, and mathematics, the three-year schooling includes courses in farm bookkeeping, land survey, soil analysis, and basic farm engineering. In addition, all students receive elementary instruction in anatomy, physiology, hygiene, and first aid, with particular emphasis on the treatment of common tropical diseases such as malaria and dysentery. The study of farm economy includes courses in marketing tropical products, also farm credit and rural legislation (legal matters pertaining to enclosures, land limits, roadways, quarantine practice, livestock laws, and trade regulations).

The department of agronomy provides basic laboratory experiments in chemistry and geology, which is followed by training in classification of soils and the use of fertilizer and crop rotation techniques as adapted to common needs of the American tropics. The forestry course includes the replanting of native trees, the establishment of tree nurseries, and the transplanting of small trees from nurseries to open woodlands. The course in agriculture begins with practical instruction in the propagation of common plants by means of seed, sprouts, bud grafting, and rhizomes. Each student prepares and cares for several hundred grafted fruit trees including oranges, mangoes, and avocados, with all trees becoming the student's property at the time of his graduation. The courses in practical gardening include the planting and management of home gardens and the production of green vegetables to sell; also the study of the nutritional value of the common vegetables.

The farm engineering department directs the study of irrigation and drainage; doubly important in Caribbean lands where drainage is practically essential to all crops of the wet tropics and in most highland areas where well planned irrigation helps assure larger, more uniform, and more profitable harvests. The courses in farm engineering also teach the use and care of farm machinery, including tractors and tractive implements as well as the standard hand tools and horse-drawn implements. Instruction in home carpentry and farm blacksmithy is included; also in building and maintaining roads. The

department of animal industries provides practical tutelage in breeding and keeping cattle, horses, mules, swine, and poultry in the American tropics, where livestock resources remain chronically insufficient. Practical work in animal health includes the study of principal contagious and infectious diseases and parasites of livestock in the tropics.

In the United States the opening of another professional school is not necessarily newsworthy. But south of the Rio Grande agricultural, mechanical, and engineering schools are still in dire shortage, and poor country youths have slight chance of attending the national universities. In general, too, Latin American college and university training remains centered in law, medicine, and the classics. Though more than four-fifths of the lands of the other Americas are tropical and though at least 70 per cent of all Latin Americans live from farming, scientific education in tropical agriculture remains lamentably scarce. Meanwhile the technical and commercial problems in tropical agriculture are growing almost fabulously. Defense of basic crops and livestock against fungi, pathogenic microorganisms, and insect enemies becomes an unending and ever more difficult obligation. Problems of soil conservation grow at a terrific rate.

Furthermore, the new crops now finding their way into the economies and agricultures of the American tropics—including such promising export commodities as abaca, cinchona, essential oils, strategic timbers, rotenone, rubber-bearing plants, and urgently needed tropical fruit crops—require more and better research and experimentation. The proposition grows ever more evident that if Latin American citizen farmers are to grow, develop, and benefit from the great crops now being proved in the New World, the indigenous farm youth must be helped to learn the demanding techniques of modern tropical agriculture. Escuela Agricola Panamericana is a first deliberate answer to this challenge and need.

Arnulfo Mercado and the seventy-two other Central American and Mexican youths know how urgently and desperately their countries need technical education in agriculture. At first hand they have witnessed

SCHOOL PASTURES AND RANGES DEVELOPED FOR STUDENT USE

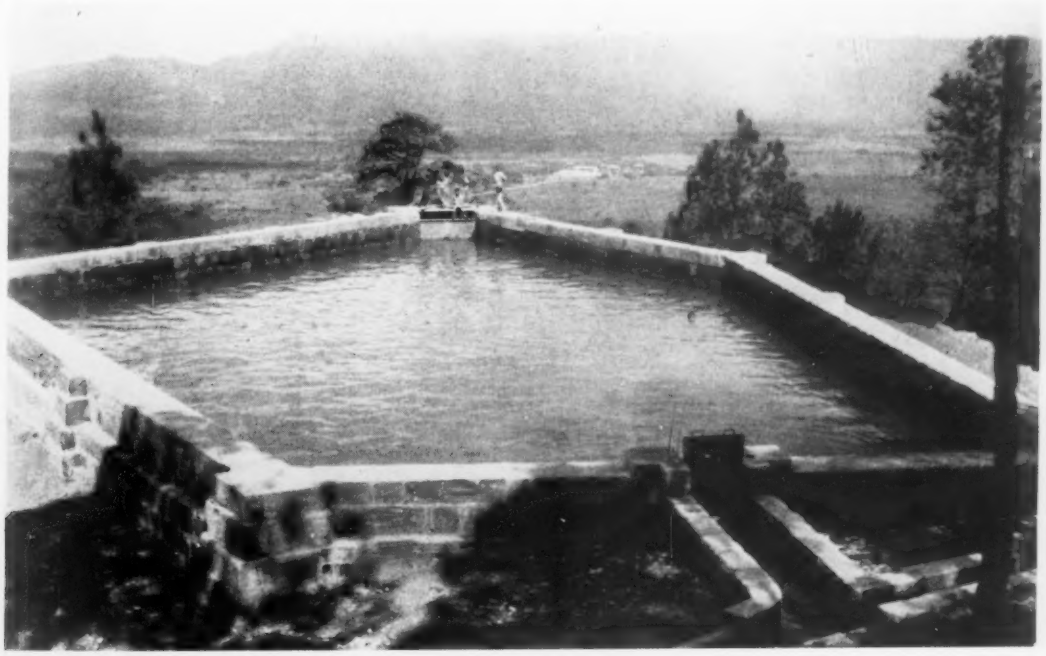
the needs. And not one of them is too young to know that agriculture succeeds because of the sweat, toil, intelligence, and skill of the citizen farmer, particularly the small farmer. Accordingly, Arnulfo and his associates are hard at work and hard at play at a school which they know is in and of Honduras and Central America.

The food, the language, the gaiety of the backwoods, indeed, the architecture are those of the American tropics.

The four dormitories (the first is completed and occupied) are named to honor great heroes of Central America—Morazan of Honduras, Barrios of Guatemala, Mora of Costa Rica, Delgado of El Salvador. All buildings are made of local products, by home talents and native labor; a force of about five hundred Central American workers who quarry, kiln, saw, and build with materials immediately at hand. Power and light are supplied from the school's hydroelectric plant already completed on the higher reaches of the Yeguare River. The infirmary, now in building, will include an emergency hospital, a clinic room, a dental clinic, and a barber shop. The school has a staff barber who administers one free haircut to every student once a month; and more significantly, a physician-surgeon. Prior to their arrival at the school, few of the students had any dental attention and almost all require dentistry, which is being provided.

Student health is excellent and appetites are lusty. Arnulfo and his fellow students are learning how to plant, till, and harvest the good foods which nourish them. Even during the beginning year the school is producing most of its foodstuffs. Fields and gardens are already planted and in bearing. Livestock holdings are ample to meet the needs of both students and workmen. Already garden crops and other staple food crops have been adapted from various nearby Americas; melons from Cuba, sweet corn from Puerto Rico, grafted avocados from California and Mexico; white potatoes from Florida; tomatoes and leafy vegetables from various areas of southern United States.

Accordingly, Arnulfo and his freshman classmates have opportunity to benefit by good eating, which in Honduras or anywhere else is the maximum dividend of good agri-



WATER STORAGE FOR OPERATING THE 40-KILOWATT POWER PLANT

culture. That is a cosmopolitan goal and these young men of the American tropics are aided by a cosmopolitan faculty. For example, the head of the department of agronomy and soil is Alfred F. Butler, co-builder of the Lancetilla Experiment Station of Honduras, an English trained agronomist. H. A. Von Wald, of the University of Wisconsin, is head of the department of engineering. The head of the livestock department is E. A. Rivera, a native Puerto Rican, a graduate of the College of Agriculture of Mayagüez, Puerto Rico, and recently director of the livestock and dairying department of the Venezuelan Government. The professor of natural sciences is a Costa Rican, until recently the director of the National Museum of Costa Rica. The professor of English is Augusto Arias, a Guatemalan. The professor of horticulture and director of the school is Dr. Wilson Popenoe, internationally known authority on tropical agriculture; a former associate of the U. S. Department of Agriculture.

The seven regents of the school, five of whom are Central Americans, select the scholars, who must be proved thoroughly accredited as to good character, industry, and general intelligence. Thus far all admissions have been of poor boys. The school would thwart its purpose by accepting or requiring money from students. It cannot directly imitate the curricula or establishments of any college in the United States, however meritorious, since an excellent United States college is rarely, if ever, the right school south of the Rio Grande. Therefore it must create a new formula for practical Pan American education, a task which it is now undertaking.

SHALL WE SPEAK OUT?

From multiplex experiential fronts
We must at times to inner room withdraw
And ponder meaning in some hope to see
Synthetic bits of universal law.

Too oft emerging from that cell to light
We bring no message, yet discern the flaw.
Upon that page our shadows fell so dark
That what we drew but outlined what we saw.

At times the ego merges with the All
And lets the light of truth prevail.
Then do we feel impelled to sing
Or picture nature's wondrous tale.

Is this so strange for those immersed
In scientific lore, whose life is spent
In analytic test and measurement,
Of changing form and planned experiment?

Truth comes in many forms, and beauty too,
May peer from graphs and metric formulae.
The reach of mind beyond its data soars
To make its greatest gains, and we are free
To test and seek some more.

Mankind is still emotion geared
With hymns of hate and love.
Behind the scenes stalk want and fear
And over all the crowding sphere
The master problem proves.

So therefore build and carve and draw,
Deduce, conclude and write as law
What seems so clear to you.
Fear not to seem beyond the pale
For yet no sacred mode prevails
To voice a message true.

—JOHN G. SINCLAIR.

UTILIZATION OF SEAWEEDS*

By C. K. TSENG

INQUISITIVE children often ask their elders about the heaps of rotten plants washed ashore on the beach. A typical answer is, "Oh, they are seaweeds." To most persons who enjoy swimming or strolling along the beaches seaweeds are very unwelcome. Probably when the early Latin scholars, such as Virgil and Horace, spoke of these plants as "*villior alga*," they had the same feeling too, for could there be anything more worthless and noxious than the seaweeds which spoiled the otherwise clean and lovely beaches? In fact when a Roman had said that something was more worthless than an "*alga*," he had probably gone as far as the Latin language could carry him!

The thrifty Orientals, however, have quite a different attitude toward marine growths. Although they too regard most of the marine plants as weeds, they call certain kinds "sea vegetables." The latter are so highly esteemed as food that natural production is not sufficient to satisfy the demand for them and consequently they are cultivated like farm crops. Moreover, some marine algae have long served as medicine and others have been employed in sizing silk and for various other purposes. To those who know the value of marine crops, it seems inconceivable that the useful forms should have been called sea "weeds."

In the last two centuries utilization of seaweeds has been gaining favor in the Western world. While the food-conscious Orientals have been using luscious marine plants chiefly for subsistence, the industrially-minded Occidentals have developed other uses. Previously they were burned to form kelp ash from which soda, potash, and iodine were extracted. Now they are processed to yield algin, agar, carrageenin, and other useful products. Few realize, however, that the United States is annually deriving millions of dollars worth of valuable products from these humble plants.

Some eighty years ago, E. C. C. Stanford, the discoverer of algin and one of the pioneers in the promotion of seaweed industries, addressed the Royal Society of Arts in London on the economic applications of algae. The following statement made by the chairman after the lecture could represent the opinion of those who have come to realize the value of marine plants:

> It had been remarked by those who noticed the progress of invention that language generally had to undergo changes corresponding with the changes of the times. Now he, for one, wished that the word "weed" should cease to be applied in the indiscriminate manner it was to marine plants. Hitherto "weed" meant a useless or noxious plant. Mr. Stanford had shown that a vast proportion of marine plants, so far from being "weeds" in the ordinary conception of the word, were extremely useful "vegetables"; and he hoped they would come before long to limit the word "weed" to those marine plants which were worthless, or which were not capable of being turned to accounts.

Unfortunately, there is as yet no simple word to take the place of "seaweed" in its general sense so that we might differentiate between the useful and the useless plants of the sea. Illogically we still have to use the term "seaweed" in the same indiscriminate way that was criticized almost a century ago, unless we want to use the more technical combination, "marine algae."

To people who have never enjoyed the taste of some delicious sea vegetables it may seem inconceivable that seaweeds or their products could be eaten. Nevertheless, they are unconsciously consuming certain seaweed products, which have, in recent years, entered into our daily diet. To mention some examples: many types of confectionaries, canned goods, the so-called health foods, and practically all ice cream and chocolate milk contain seaweed extracts.

USES OF SEAWEEDS

The chief uses of seaweeds may be classified under the following five categories: foods, drugs, gums, chemicals, and stockfeed and fertilizer.

Foods. More than one hundred kinds of

* Contributions from the Scripps Institution of Oceanography, New Series, No. 229.

About one-fifth actual size

FIG. 1. *LAMINARIA JAPONICA**

YOUNG JAPANESE KELP PLANT FROM CHEFOO, CHINA, A COMMON FOOD SEAWEED ON THE ORIENTAL MARKETS.

marine plants are utilized as food by the Chinese, Japanese, and Hawaiians. Of these kelp and purple laver are consumed in larger quantities than all the others combined.

The edible kelps in the Orient are species of *Laminaria*, *Undaria*, and *Ecklonia*. The most important is *Laminaria japonica* (Fig. 1), which is known in China as *haitai* and in Japan as *kombu*. The Japanese probably eat their kelp as regularly as the Americans eat their lettuce and tomatoes. The Chinese do not consume as much kelp as the Japanese, because China produces only small quantities of it. Annually, she has imported about 55 million pounds of *haitai* from Japan, and in spite of its foreign origin, it has been sold in the inland provinces thousands of miles from the ports of entry.

The purple lavers are members of the genus *Porphyra*, called by the Chinese *tsuts'ai* and the Japanese *amanori*. The demand for this group of sea vegetables, especially *Porphyra tenera* (Fig. 2), is so great that natural production both in Japan and in China is not enough to meet the demand. Consequently, it is extensively cultivated in Japan, where a total area of over twelve thousand acres is devoted to *amanori* farming. Annually over 65 million pounds of this seaweed, valued at about 9 million yen (about $3,000,000), were produced, some of which was exported to China.

Scientists do not entirely agree on the food value of seaweeds. Experiments have shown that some seaweed carbohydrates are not easily digested by humans because of the absence of suitable enzymes in the alimentary tract. Research on others indicates a rather high degree of digestibility. We still do not know enough about the actual nutritional value of seaweeds. Possibly, like the land plants, some have a high nutritive value whereas others have very little or even none.

Seaweeds are comparable to lettuce and celery. Whether they have high nutritive value in the sense of supplying energy and building tissue is of secondary importance. Because they are stimulating or appetizing

About one-fourth actual size

FIG. 2. *PORPHYRA TENERA*

THE PURPLE LAVER OF THE ORIENT, ANOTHER COMMON EDIBLE SEAWEED ON THE MARKETS OF THE FAR EAST.

* Figures 1, 2, 3, 6, 7, and 8 are reproduced through the courtesy of Professor Wm. Randolph Taylor, University of Michigan.

because they supply necessary salts in readily available organic form, and because they furnish vitamins, seaweeds should have a place among common foods.

It is possible that a seaweed diet may be a preventive for hay fever. Although plants having more virulent pollens than those from the American ragweeds are found to occur in Japan and coastal regions of China, yet these areas have few hay fever cases. But Orientals are not immune to such allergy; in fact, many of them become hay fever victims after having stayed in the United States for some time. It is generally accepted that potassium chloride may help to alleviate suffering from hay fever. Since the Japanese and the Chinese eat many kinds of seaweeds that contain large amounts of potassium chloride, it is probable that the custom of eating seaweeds may be responsible for the suppression of hay fever in the Orient.

Drugs. The Chinese *Materia Medica* has recommended, from early days, the use of seaweeds, especially the kelps and the sargassums, in the treatment of goiter and other glandular troubles. These plants have also been used in the treatment of dropsy. The ancient peoples, of course, did not know why such seaweeds were so effective in curing these maladies. They found out the special value of the humble marine plants merely by trial and error. Now, the curative principle is known to be iodine.

About one-half actual size

FIG. 3. *DIGENEA SIMPLEX*

FROM CHINA. AN IMPORTANT ORIENTAL DRUG PLANT FROM WHICH MACNIN AND HELMINOL ARE EXTRACTED.

About one-half actual size

FIG. 4. *GELIDIUM AMANSII*

A YOUNG CYSTOCARPIC SPECIMEN OF THE PRINCIPAL AGARPHYTE IN THE ORIENT. FROM TSINGTAO, CHINA.

A well-known drug on the Oriental market is the tropical seaweed, *Digenea simplex* (Fig. 3), known in China as *Tserkoo-ts'ai* or *Haijen-ts'ao*. In recent years the Japanese have prepared a drug from it called *macnin*. A pharmaceutical under the name of *helminol* also comes from the same source. It is said to be as effective as the standard vermifuge, santonin, and, because it has no secondary bad effect, especially on children, it is rated as better.

Gums. Seaweed gums are hydrophilic colloids which form mucilaginous sols or firm gels in water at low concentration. Agar, algin, carrageenin, and funorin are the four kinds of gums made from seaweed sources. Because of their peculiar properties, they have been used extensively as stabilizers, deflocculants, textile sizers, and semielastic media. Their commercial importance has increased rapidly in recent years.

Agar is extracted principally from species of *Gelidium* (Fig. 4). Although agar in the

About one-fifth actual size

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FIG. 2. *PORPHYRA TENERA*

THE PURPLE LAVER OF THE ORIENT, ANOTHER COMMON EDIBLE SEAWEED ON THE MARKETS OF THE FAR EAST.

* Figures 1, 2, 3, 6, 7, and 8 are reproduced through the courtesy of Professor Wm. Randolph Taylor, University of Michigan.

because they supply necessary salts in readily available organic form, and because they furnish vitamins, seaweeds should have a place among common foods.

It is possible that a seaweed diet may be a preventive for hay fever. Although plants having more virulent pollens than those from the American ragweeds are found to occur in Japan and coastal regions of China, yet these areas have few hay fever cases. But Orientals are not immune to such allergy; in fact, many of them become hay fever victims after having stayed in the United States for some time. It is generally accepted that potassium chloride may help to alleviate suffering from hay fever. Since the Japanese and the Chinese eat many kinds of seaweeds that contain large amounts of potassium chloride, it is probable that the custom of eating seaweeds may be responsible for the suppression of hay fever in the Orient.

Drugs. The Chinese *Materia Medica* has recommended, from early days, the use of seaweeds, especially the kelps and the sargassums, in the treatment of goiter and other glandular troubles. These plants have also been used in the treatment of dropsy. The ancient peoples, of course, did not know why such seaweeds were so effective in curing these maladies. They found out the special value of the humble marine plants merely by trial and error. Now, the curative principle is known to be iodine.

About one-half actual size

FIG. 3. *DIGENEA SIMPLEX*

FROM CHINA. AN IMPORTANT ORIENTAL DRUG PLANT FROM WHICH MACNIN AND HELMINOL ARE EXTRACTED.

About one-half actual size

FIG. 4. *GELIDIUM AMANSII*

A YOUNG CYSTOCARPIC SPECIMEN OF THE PRINCIPAL AGARPHYTE IN THE ORIENT. FROM TSINGTAO, CHINA.

A well-known drug on the Oriental market is the tropical seaweed, *Digenea simplex* (Fig. 3), known in China as *Tserkoo-ts'ai* or *Haijen-ts'ao*. In recent years the Japanese have prepared a drug from it called *macnin*. A pharmaceutical under the name of *helminol* also comes from the same source. It is said to be as effective as the standard vermifuge, santonin, and, because it has no secondary bad effect, especially on children, it is rated as better.

Gums. Seaweed gums are hydrophilic colloids which form mucilaginous sols or firm gels in water at low concentration. Agar, algin, carrageenin, and funorin are the four kinds of gums made from seaweed sources. Because of their peculiar properties, they have been used extensively as stabilizers, deflocculants, textile sizers, and semielastic media. Their commercial importance has increased rapidly in recent years.

Agar is extracted principally from species of *Gelidium* (Fig. 4). Although agar in the

About one-fifth actual size

FIG. 5. *MACROCYSTIS PYRIFERA*

YOUNG GIANT KELP PLANT, FROM WHICH ALGIN IS MADE IN CALIFORNIA. SPECIMEN FROM LA JOLLA.

form of a jelly has been eaten by the Orientals for ages, it was not until the middle part of the seventeenth century that the process of preparing its dried form by a simple freezing and thawing method was accidentally discovered in Japan. As a stabilizer and a gel-forming substance agar has numerous applications. In some of its special uses there is as yet no successful substitute. Since the outbreak of the war it has attracted considerable attention in this country. More than 90 per cent of the agar consumed in the United States formerly came from Japan. Since the war the California agar industry has greatly increased its production and is now making enough agar for essential uses in this country.

The most important service that agar renders to mankind, in war or in peace, is as a bacteriological culture medium. In dentistry it serves as an impression mold. Its extraordinary water-holding ability makes it valuable in wound dressing and as a laxative. In the photographic industry it replaces gelatine for certain types of films. In the hot drawing of tungsten wire agar is used in making a special lubricant to facilitate the operation and to reduce the wear on the die. It is also extensively used in bakery products, in clarifying liquids, in making health foods, in confections, and in ice cream. Recently it has been used in the manufacture of marine storage batteries.

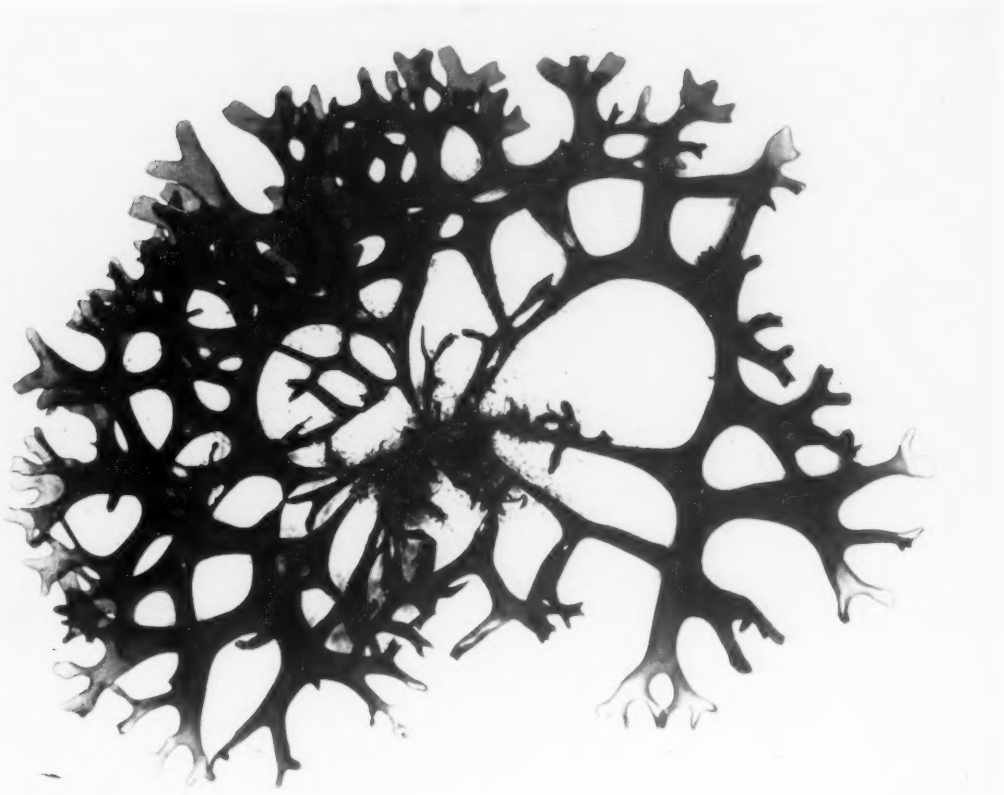
Algin is derived from the giant kelp, *Macrocystis pyrifera* (Fig. 5), on the West Coast, and from various species of *Laminaria* (Fig. 6) on the East Coast as well as in England, France, and Japan. The term generally refers to the water-soluble salts of alginic acid, especially sodium alginate. It was discovered in 1883 by the English chemist, E. C. C. Stanford.

The important use of algin is as a stabilizer in the manufacture of ice cream. It is also a valuable agent for thickening, emulsifying, suspending, and coating various sub-

About one-fifth actual size

FIG. 6. *LAMINARIA SACCHARINA*

FROM WEST BARNSTABLE DUNES, MASS. A VALUABLE EAST COAST KELP FOR THE EXTRACTION OF ALGIN



About actual size

FIG. 7. *CHONDRUS CRISPUS*

THE WELL-KNOWN IRISH MOSS OF THE ATLANTIC COASTS, A SOURCE OF THE GUMLIKE SUBSTANCE, CARRAGEENIN.

stances. It is used in camouflage paints, fire-proofing compositions, latex coating for signal wires, and water-treating compounds. It is also utilized in making pharmaceuticals. Recently discovered is its use as a coating for oilproof paper containers.

Carrageenin is the cold-water-soluble extract from Irish moss, botanically *Chondrus crispus* (Fig. 7). The seaweed itself was used extensively and exclusively, in earlier times, to prepare the well-known dessert, blanemange. About a hundred years ago the United States used to import large quantities of this seaweed from Europe at a cost of as much as two dollars a pound. It was later discovered that the same plant grew in great abundance in the cooler waters of the Atlantic Coast. For the past century, Scituate, Massachusetts, has been the center of the American Irish moss industry. Lately, large quantities have also been harvested in Maine. A recent estimate placed the production of *Chondrus* on the Atlantic Coast at about five million pounds per annum. It is generally agreed that Irish moss extract is one of the best agents for stabilizing the chocolate fibers in making chocolate milk.

Funorin is the gluey substance in the seaweed *Gloiopeltis* (Fig. 8), known as *funori* in Japanese and *hailo* in Chinese. Commercially, the entire, dried, frequently bleached seaweed is used without extracting this gluey principle from the plant. It is readily soluble in lukewarm water and may be identical with, or at least closely related to, the Irish moss extract. It is mainly used in sizing textiles, especially silk, and in this respect is said to be better than carrageenin. Japan produces about four and a half million pounds annually. China, although the second largest producer, also imports some from Japan to supplement her insufficient supply.

About one-third actual size

FIG. 8. *GLOIOPELTIS FURCATA*
FROM CHEKIANG, CHINA. IN THE ORIENT A GLUE OBTAINED FROM IT IS USED FOR SIZING TEXTILES.

Chemicals. During the eighteenth century one of the chief sources of potash and soda in Europe was seaweed ash. At the beginning of the nineteenth century, Scotland alone produced annually about twenty thousand tons of kelp ash, worth about forty thousand pounds sterling. When the manufacture of soda from common salt commenced early in the nineteenth century, the value of seaweed ash dropped rapidly. With the discovery of iodine in 1812, the value of kelp gradually increased until 1873 when iodine began to be recovered from the mother liquors obtained in the manufacture of sodium nitrate from *caliche*. The kelp industry then declined for the second time. The first World War stimulated the revival of the kelp industry in the United States and in other countries as a source of badly needed potash, which used to be a German monopoly, as well as iodine, acetone, and calcium acetate. Soon after the cessation of hostilities, the kelp factories folded up, and the industry declined for the third time. At present potash, iodine, and other chemicals are still being produced from kelps in some countries, but in the United States it is no longer profitable to do so.

The seaweeds utilized in the manufacture of chemicals are the kelps, the fuci, and their related forms. In Europe and Japan they are chiefly species of *Laminaria*, *Fucus*, and *Sargassum*, and on the Pacific Coast of the United States, the giant kelp, *Macrocystis pyrifera*, is the most important one.

Fertilizer and stockfeeds. Whole or chopped seaweeds are widely utilized as fertilizers in countries with extensive coast lines, especially China, Japan, Great Britain, and France. These plants contain not only large quantities of soluble potassium compounds and some nitrogenous compounds, but also bulky organic substances which slowly decay in the soil and form humus. The seaweeds used for manures are generally the large ones, especially members of the genera *Laminaria*, *Fucus*, and *Sargassum*. In Ireland the demand for seaweed manure is so great that one species, *Fucus vesiculosus*, is specially cultivated to meet the demand. In most cases the seaweeds are collected by farmers in the vicinity of the seacoast and applied by them directly to their own fields. Because of its high potash content, seaweed fertilizer is especially beneficial to root crops such as the potato, sweet potato, and beet. As a fertilizer it is fully as valuable as barnyard manure and has the added advantage of being free from weed seeds and fungus spores.

In certain European countries herds pasturing along the seashore graze on living fuci and other algae exposed at low tide. Seaweeds are gathered, boiled, and mixed with meal, and the resulting mixture fed to horses, pigs, and cattle. In California a kelp company prepared a kelp meal from *Macrocystis*, which was found to be a good food supplement for chickens, foxes, and cattle.

The Seaweed Industry in California

California has one of the richest coasts in the world—not only in fish resources but also in marine vegetation. The value of the relatively young seaweed industry in this State is already worth at least two million dollars annually, with only a rather small portion of the potential natural production being utilized.

Agar. This extract is the only one from seaweed sources that has received the attention of the War Production Board. Two months after the attack on Pearl Harbor, this commodity was frozen and its uses restricted to the preparation of bacteriological culture media.

In California agar is extracted from the local seaweed, *Gelidium cartilagineum*, which occurs in commercially harvestable quanti-

ties from Point Conception southward. It is a reddish-purple, fern-like alga which grows on rocks from the low tide mark to a depth of thirty or more feet. It grows best in turbulent waters and in regions where there is a continuous swell. Although it may attain a height of four or more feet, it is harvestable when about one and one-half feet tall. Practically all the commercial weeds are harvested with a diving rig, only a small quantity being gathered with a long-handled rake. The diver wears a complete diving outfit and, crawling over the rocks, pulls the weed off by hand. In a good working day of about six diving hours, an experienced diver can get as much as a ton of the wet weed. Generally, however, the amount harvested per day is between 1,000 and 1,500 pounds. There are not many working days in a year, since during the winter months the ocean is usually too rough for the diver to work. Even in the summer, there may be only two days out of three when the water is calm enough for this rather strenuous and precarious work. The weed is dried in the sun and baled, but it is not bleached, as is the practice in Japan.

The California method of processing agar is much more modern than the traditional Japanese procedure, but the basic principle is the same in both: agar is soluble in boiling water but not in cold water. Thus, when crude agar gel is frozen and later thawed, the cold water draining away will carry with it the soluble salts, pigments, and various impurities. Agar may also be precipitated by alcohol and other chemicals, although this method has not yet been applied commercially. The freezing-thawing method seems still to be the cheapest one, although technologists are working on improved methods.

The first agar factory in the Western Hemisphere appeared in Glendale (formerly Tropico), California, about 1920. Strange to say, the person who founded an industry which eventually freed the United States from dependence upon Japanese agar, was a Japanese, Chokichi Matsuoka. He processed the weeds by the traditional Japanese procedure, with some minor modifications. The company apparently was not financially successful and was later sold to a group of native Americans. It remained for a Californian, the late John Becker, to modernize the agar manufacturing method. Now there are agar factories at San Diego, South Pasadena, Los Angeles, Orange, and Whittier, all in southern California. In the largest of these factories, producing about one-third of the quantity of agar previously imported by the United States from Japan, the process is as follows: The agarphyte is soaked in cleaning vats and then the agar is dissolved from the plants by hot water in pressure cookers (Fig. 9). The hot solution passes through filter presses to tubs where it gels upon cooling. The resulting gel is crushed and is poured down into cans in the freezing room (Fig. 10). The frozen gel is thawed and the cold water, in which impurities are dissolved, is separated from the agar particles in rotary vacuum filters. As the resulting agar flakes still carry about 90 per cent water, they are delivered to stack driers (cylinders three stories high) in which they are dried by an ascending stream of hot air.

Algin. The giant kelp, *Macrocystis pyrifera*, provided the United States with potash during the last war. It is now producing another important article, algin, which is likewise helping the war effort. While algin is also being produced on the East Coast, from *Laminaria*, more than 70 per cent of the total U. S. production comes from southern California.

Macrocystis is truly a giant kelp, growing to a length of over one hundred feet. It attaches to rocks at a depth of ten to seventy-five feet in regions where there is a continuous swell. Thanks to the private and government investigations conducted during and shortly before the first World War, we have a better knowledge of this seaweed than of any other useful form. At present the harvesting of kelp is highly mechanized and is effected by a mowing machine, cutting three to four feet below the surface, and carrying as much as three hundred tons in a single load. The operation is carried out in calm weather throughout the year.

The method of extracting algin is based on the fact that alginic acid itself is insoluble whereas its sodium salt is readily soluble in water. The fresh kelp is therefore digested with soda, which reacts with the acid to form

the soluble sodium alginate. This is filtered from the pulpy residue, and the subsequent addition of an acid precipitates the insoluble alginic acid. A wide variety of metallic and organic salts of alginic acid are marketed.

Porphyra. The only seaweed which has been utilized directly for food in any quantity in California is the perforated purple laver, botanically *Porphyra perforata.* This is a very common seaweed along the entire California coast. Being an annual, it generally appears in winter and spring and continues to grow until early summer. It grows on rocks in rather sheltered places to the limit of high water.

It was reported that 300,000 pounds of dried *Porphyra* were harvested in 1929 by white men and Indians in northern California and by Chinese in central and southern California. Chinese buyers distributed the products to Chinese stores or exported them to China, especially to Hong Kong and Canton. The Chinese harvesters usually came to the *Porphyra* grounds in the fall and burned, with driftwood, the rocks on which they expected their seaweed crop to grow. By early spring these rocks were densely covered with the laver. In harvesting, the seaweed is merely pulled from the rock by hand and is dried in the sun in the form of rectangular sheets.

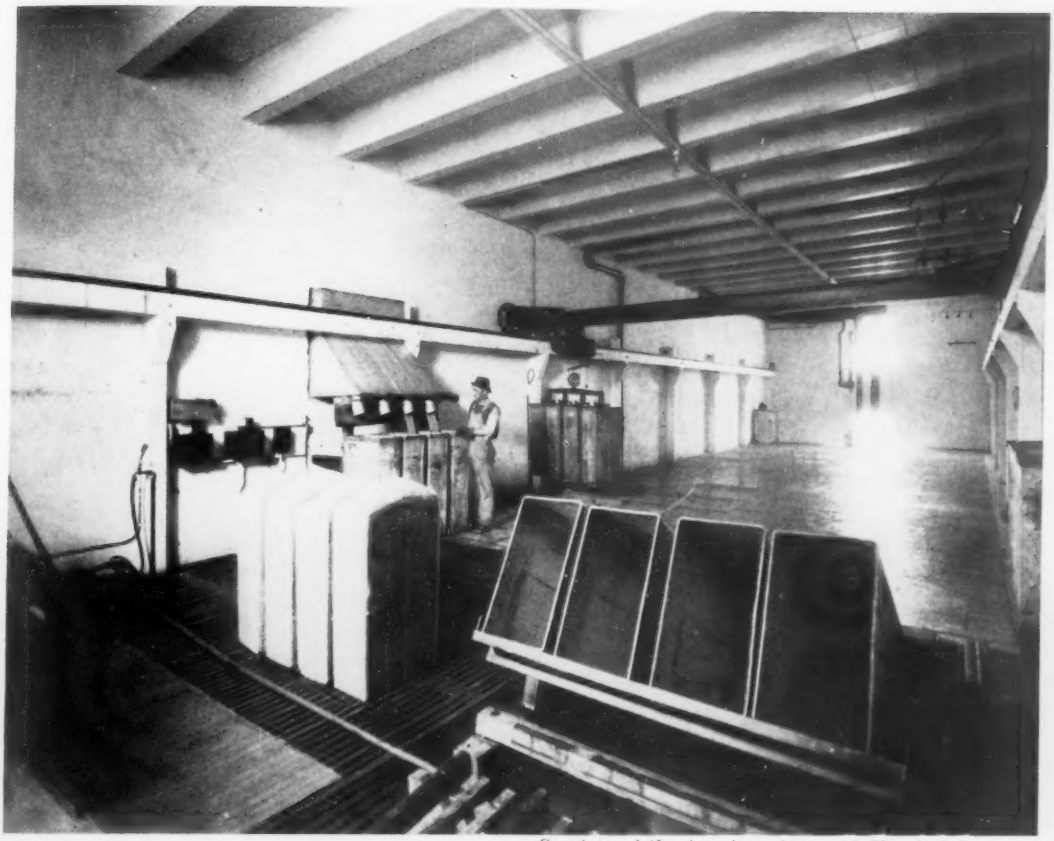
The Future of the California Seaweed Industry

It has previously been remarked that the amount of useful seaweeds now being harvested in California is only a small fraction of the total natural production. The greatest obstacle to the development of the local

Courtesy of the American Agar and Chemical Company

FIG. 9. INITIAL TREATMENT OF AGARPHYTES FOR PRODUCTION OF AGAR

SOAKING VATS ARE ON THE RIGHT, PRESSURE COOKERS ARE ON THE LEFT, AND FILTER PRESS IS IN THE REA



Courtesy of the American Agar and Chemical Company

FIG. 10. ROOM IN WHICH PARTIALLY PURIFIED AGAR-GEL IS FROZEN

THE CANS FILLED WITH CRUSHED AGAR-GEL ARE LOWERED INTO THE COLD BRINE BENEATH THE SLATTED FLOOR.

seaweed industry lies in the high cost of the raw material, because of the necessity of using human labor in the harvesting. Thanks to the efforts of scientists, especially the late Professors W. A. Setchell and N. L. Gardner of the University of California, we have a good knowledge of the kinds of seaweeds that grow on the Pacific coast, but we have neglected other phases of research on seaweeds, especially the relationship between the seaweeds and their chemical and physical environments, the life history of the red seaweeds, the development and growth of the useful species, and the technology of seaweed products. Consequently, we are still unprepared to build a great seaweed industry in California.

For several reasons the processing of kelp undoubtedly has a more promising future than that of other seaweeds: First, we have a better knowledge of the essential biology of *Macrocystis* than of any other useful seaweed. Second, scientists have estimated that we could harvest annually more than 30 million tons of fresh kelp south of Point Conception. As the kelp companies in southern California are probably harvesting only about fifty thousand tons annually, the supply of the raw material for the future expansion of the industry is practically unlimited. Third, the demand for algin as a stabilizer is continuously increasing, and new uses for it are also being found. Finally, the harvesting of kelp has been highly mechanized, thus reducing greatly the cost of the raw material.

The agar industry faces a much more difficult future: First, we still know very little about the growth, reproduction, physiology, and life history of the agarphyte, *Gelidium cartilagineum*. Second, the harvesting of this seaweed must be effected entirely by manual labor and below the surface of the

sea. Furthermore, it is not easy to collect because it generally grows in small patches and usually clings to the ragged edges of rocks. A practical mechanical device to harvest it has not yet been invented, although thousands of dollars have been spent in the attempt. As a result, the cost of fresh *Gelidium* is almost fifty times that of fresh kelp. Third, the threat of Japanese competition after the war makes American interests reluctant to invest money in an industry which may collapse in the face of cheap foreign imports. In some past years it has been reported that the agarphyte harvested in California cost almost as much as the finished agar imported from Japan. Fourth, although California agar is much more carefully and scientifically manufactured than the Japanese product, our present manufacturing method still needs numerous improvements. For instance, a significant portion of the agar now remains in the discarded pulp after cooking—a portion which should be recovered.

During the present war emergency there is no Japanese competition, and the government is buying agar at three dollars a pound. After the war, however, conditions may be very different. If the California industry cannot produce a cheaper agar, it will be doomed to failure. In fact, in its twenty-three years of existence the American agar industry has persisted only through periodic injections of new capital and has several times been at a standstill. Fortunately, through the persistent effort of a few persons like the late John Becker, and also because of the high quality of the local product, California had, at the outbreak of the war, a skeleton agar industry. In the interest of future national defense, the agar industry should be encouraged to attain a permanent status. This can be achieved in part by research on the biology of the principal agarphyte, *Gelidium cartilagineum*, and also by research on the technology of manufacture. Another possible solution of the problem is to find other agar-bearing seaweeds which can be gathered at a lower cost than *Gelidium*. Recently it was found that *Gracilaria confervoides*, one of the seaweeds used in agar manufacture in other countries, occurs in large quantity in bays in southern California. From this plant, a much cheaper agar can be produced, because of the relatively low cost of harvesting it. The Gracilaria-agar seems to be poorer in quality than the Gelidium-agar; however, it should be useful as a substitute for the latter in certain fields. South Africa and Australia are already producing agar-gel from *Gracilaria*. England is also reported to be trying to make her own agar from a local seaweed, probably the same plant. On the East Coast, some Gracilaria-agar has already been produced and offered for sale. Utilization of the West Coast *Gracilaria* will greatly increase the local production of agar and may also help to reduce its cost.

When Americans have come to realize that some seaweeds, *Porphyra* for instance, are palatable and just as delicious as some of the vegetables, the seaweed food industry will certainly have a promising future. At present the consumption of *Porphyra* as food in this country is limited to Orientals, especially the Chinese. "Wild" purple laver is abundant on the coast of California. Moreover, this plant can always be cultivated without much difficulty and on a large scale if the natural supply is not sufficient to satisfy the demand.

Besides *Macrocystis*, *Gelidium*, *Gracilaria*, and *Porphyra*, California has many other kinds of potentially useful seaweeds. For instance, there are several species of *Gigartina* and *Iridophycus* which contain a seaweed gum very similar to, and probably identical with, carrageenin extracted from Irish moss. Large quantities of these medium-sized seaweeds are found in various places on the Pacific Coast, especially in the latitude of Monterey. I once gathered from the rocks about eighty pounds of *Gigartina corymbifera* in only fifteen minutes at low tide.

In order to achieve a successful, permanent seaweed industry in California it is highly desirable to carry on further research on the biology and life history of the useful species, on the ways and means of utilizing them, on the harvesting methods, and on the technology of extracting the unique substances present in these marine crops.

PROTEINS: THE MACHINES OF LIFE

By M. F. PERUTZ

On a recent visit to the United States I was greatly impressed by the proficiency which Americans display at designing, constructing, and operating all kinds of mechanical devices. The stranger is led to the conviction that Americans are born with an understanding of machines; indeed, it would not have surprised me in the least to see a baby driving its own perambulator.

However, much as I admired the ingenuity of American machines, I could not help thinking how very simple even the most complex man-made machines are if we compare them with the machines that make man or any other living organism.

One of the most startling developments of modern America is mass production. Yet mass production has merely copied the workings of life by developing a much higher degree of specialization than had been known before. If we try to draw an analogy between a factory and a living organism, then the brain may be compared to the administrative offices combined with the main switchboard, or the heart to the engine room.

As in a large factory, each of these organs is itself a complex department, and the tasks it has to perform are distributed among a great number of specialists. In the last resort it is found that any particular physiological function is fulfilled by chemical compounds or molecules specially designed for the purpose. Such specialist molecules may consist of atoms numbering between ten and a hundred thousand, and each kind is usually capable of doing one job and one job only.

Alcoholic fermentation by yeast may be quoted as an example of the extreme to which specialization is carried in nature. I learned at school that yeast contains an enzyme called zymase, which turns glucose into alcohol and carbon dioxide. In the meantime biochemists have discovered that in its transformation to alcohol the glucose passes through at least a dozen intermediate stages, and that each chemical reaction leading from one stage to the next is induced by a different enzyme which specializes on this reaction only. Thus the supposedly simple enzyme has become a complex system of different enzyme molecules, each doing its own job.

The great majority of these specialist molecules are proteins; that is to say, they belong to the group of substances which make up the bulk of the animal body. Bones, muscle, skin, hair, all consist mainly of protein. Proteins are capable of providing the living organism with mechanical strength and protective cover and of fulfilling a vast variety of chemical functions.

Although the constitution of this most interesting and versatile group of chemical compounds has been the subject of inquiry amongst biochemists and physiologists for many decades, our knowledge of them is still in a rudimentary stage. The trouble is that they are so large; much larger than the molecules which chemists usually handle. The latter consist of some tens of atoms or at the most of some hundred, whereas the smallest known protein molecule contains nearly a thousand atoms and some of the giant ones may contain several hundred thousand. The ordinary methods of chemical analysis break down when we try to apply them to molecules of such gigantic size; new methods had to be developed to cope with problems of this unprecedented complexity, giving rise to a new branch of science, the physical chemistry of proteins.

The first great protein chemist was Emil Fischer. He discovered that the fundamental constituents of all proteins—the bricks, as it were—are the same and belong to a group of substances called amino acids. Figure 1 shows examples of two different amino acids; actually there are twenty-three different kinds of amino acids known with certainty at present. Strictly speaking, two of them are *imino* acids, but that recondite chemical difference may here be disregarded. Each amino acid contains at least one amino (basic) and one carboxyl (acidic) group which enable it to form salts with both acids and bases.

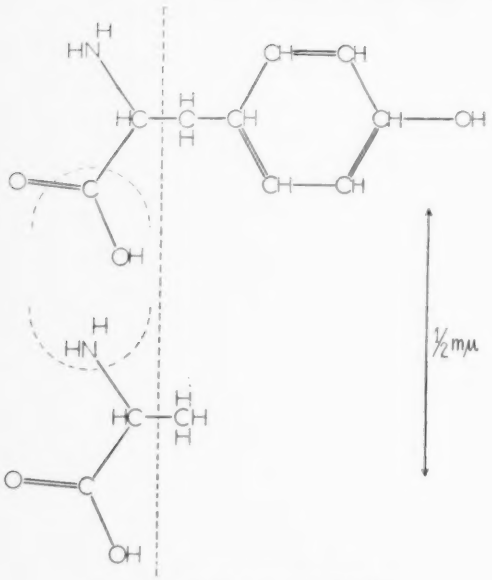


FIG. 1. TWO AMINO ACIDS
TYROSINE ABOVE; ALANINE BELOW. SAME GROUPS ON LEFT OF LINE; DIFFERENT SIDE CHAINS ON THE RIGHT.

The twenty-three different kinds are distinguished by the nature of their side chains which are attached to the second carbon atom. Fischer put forth the bold hypothesis that proteins consist of amino acids joined end to end to form chains, the joint being made between the acidic group of one amino acid and the basic group of the neighboring one (Fig. 2). This kind of joint was known as a "peptide bond," and Fischer therefore called the chains built up by joining amino acids in this way polypeptide chains.

He succeeded in producing such chains artificially and demonstrated that the synthetic product had many properties in common with natural proteins. Since the time when Fischer did his fundamental work at the beginning of the century, his results have been confirmed and extended in many directions, particularly by Bergmann at the Rockefeller Institute for Medical Research in New York.

Despite the relatively small number of fundamental constituents, polypeptide chains show such versatility that it took scientists a long time to realize all their possibilities. Let us consider these for a moment. In a chain containing a total of twenty-three amino acids, each of them of a different type, these acids can be arranged in 13×10^{21} different ways. If the chain contains several hundred amino acids, then the possible number of different arrangements of the twenty-three types is hardly conceivable.

This is not all. Quite apart from the possibilities of chemical variation, a tremendous variety of geometrical configurations enable proteins to fulfill almost any mechanical or chemical function in the organism. Polypeptide chains may form straight bundles or coil up in one plane or fold up in space in an almost infinite variety of different ways. Each of these configurations will give rise to different physical and chemical properties.

The simplest configuration which polypeptide chains can assume is a bundle of straight chains. If the chains are very long, the bundles will tend to form fibers. Natural silk, for example, consists of bundles of straight polypeptide chains (Fig. 3). The silkworm prefabricates these chains in soluble form in his silk glands before spinning them into a cocoon of strongly resistant fibers, in order to protect himself during pupation.

In other fibers, where elasticity rather than rigid strength is required, folded chains may be bundled together into fibers. Stretching unfolds these chains which act like coiled springs and fold up again as soon as the fiber is released. Animal hair, feathers, nails, horns, and such are all built on this pattern.

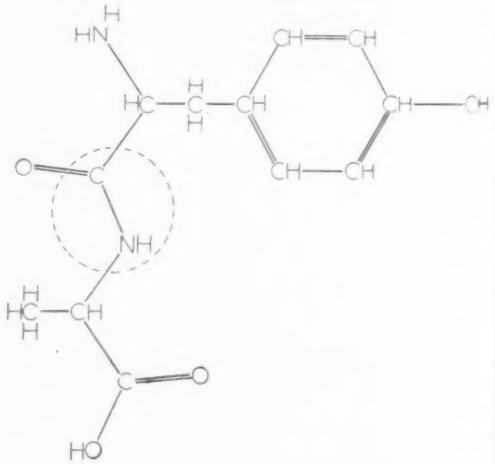


FIG. 2. AMINO ACIDS LINKED
TYROSINE AND ALANINE ARE NOW JOINED BY MEANS OF A PEPTIDE BOND, SHOWN INSIDE THE DOTTED CIRCLE.

If hair is heated excessively, the elasticity of the molecular springs is destroyed, and the hair becomes permanently set; a property which hairdressers discovered long before the scientists and which they used for providing ladies with permanent waves. Elastic bundles of polypeptide chains also play a most important part in muscle; this consists mainly of a fibrous protein, called myosin, which actually expands and contracts with every twitch of the muscle.

It has been mentioned that polypeptide chains can also form two-dimensional fabrics or networks. Such networks probably occur in the membranes of cells, but so far little is known about them.

The most important proteins are the globular ones where the polypeptide chains are arranged in the form of a three-dimensional network. Their part in the organism cannot be too highly stressed. It is almost true to say that plant and animal life consists of the sum total of the activities of globular protein molecules. They are as vital to amoebas as they are to the existence of mammals. They are the machines of the living organism. In this article I shall endeavor to show some of the tasks which they perform and, as far as our very limited knowledge permits, describe the mechanism by which they do it.

The variety of properties which globular proteins may exhibit is as endless as the number of configurations which a polypeptide chain can assume. Nevertheless there are some characteristics which are common to many proteins and one of these is solubility. Most of the globular proteins are more readily soluble than the fibrous ones; this is not surprising, for to be effective as enzymes or carriers of oxygen, proteins have to be dissolved in the body fluids. This solubility is easily lost by heating, which coagulates them and destroys their biological activity.

The boiling of an egg, for example, not only coagulates the proteins in the egg, but it also makes it impossible to hatch it. The difference between an intact protein and a boiled one seems to be that in the former the polypeptide chains are arranged in a definite pattern and form molecules of specific weights and dimensions, whereas the boiled proteins merely consist of tangles of chains of indefinite length and shape.

We can picture the process of coagulation if we imagine that heat makes the neatly ordered chains wriggle so violently that they unfold and get entangled with their neighbors in the process. Once the orderly configuration of the chains is lost, we cannot restore it, even if we try to disentangle them by redissolving the coagulated proteins in strong acid.

Protein molecules are much too small to be seen under any microscope; their size and shape, therefore, have to be inferred indirectly. The weight of the smallest known protein molecule, secretin, is about 5,000 times greater than the weight of a hydrogen atom; that of the largest one, haemocyanin, nearly 7,000,000 times greater. If we regard the molecules as spheres, then their diameters range between 2.3 and 25 mμ (mμ means a millimicron and is equal to a millionth of a millimeter).

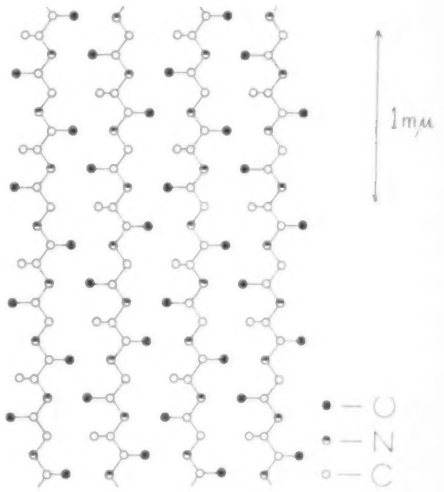


FIG. 3. STRUCTURE OF SILK FIBER
BUNDLE OF STRAIGHT POLYPEPTIDE CHAINS AS IT PROBABLY OCCURS IN FIBERS OF NATURAL SILK.

In order to give a better idea of the smallness of a protein molecule, we may compare its diameter with that of an ordinary pin's head. The number of protein molecules of the smallest size that could be accommodated in the volume of a pin's head is about the same as the number of pins' heads that could

FIG. 4. HAEMOGLOBIN CRYSTALS
PHOTOMICROGRAPH OF CRYSTALS FROM BLOOD. THEY MAY RANGE IN LENGTH FROM 0.01 TO 0.5 MILLIMETER.

be packed into a sphere of the diameter of La Guardia Airfield in New York.

Many proteins form crystals as beautifully shaped and as transparent as snowflakes. A protein can in fact be identified by the shape of its crystals. This was shown very effectively by two Americans, Reichert and Brown, who photographed the crystals of haemoglobin from nearly all vertebrates and found that their shape varied from species to species (Fig. 4). The difference between crystal types becomes greater the further removed two species are from each other.

The different crystal types merely express the individual features which distinguish protein molecules from each other. What these features are can only be surmised at the moment, but the discovery of the individuality of proteins, or specificity as it is usually called, has given rise to most of the spectacular developments in medicine. The practice of vaccinating or inoculating people against certain diseases derives its scientific background from the specific reactions of proteins.

In 1796 Edward Jenner, a physician in Berkeley, Gloucestershire, made a vital experiment. He had noticed that dairymaids whose hands showed small pustules from cowpox remained unaffected while an epidemic of smallpox swept the countryside. Jenner tried to transfer the dairymaids' resistance against smallpox by inoculating a boy in the arm from the pustule of a young woman who was infected by her master's cow. The experiment was successful, and the boy remained immune against the smallpox.

Today, we vaccinate babies with cowpox soon after they are born; as a result smallpox, once a dreaded disease killing hundreds of thousands every year, has practically vanished from the civilized world, and many other once menacing infections have been rendered harmless by timely vaccination.

How does vaccination protect? To vaccinate against a certain disease small quantities of either dead bacteria or bacterial extracts of a nonvirulent form of the disease carried are usually injected. As soon as these foreign particles invade the organism, an intricate system of defence is set in motion, and a special blood protein called gamma-globulin becomes sensitized against the intruders. If, after a lapse of time, the same intruders invade the blood stream in more formidable numbers, then the sensitized globulin molecules will at once set upon them and herd them together into impotent clots which can easily be eliminated from the system.

A remarkable feature of the sensitized globulin molecules is their specificity. They will only react with the particular type of intruder against which they were sensitized and with no other. If the sensitized globulin is so specific, how is it then that vaccination with cowpox will protect us against smallpox? It so happens that the cowpox virus is such a very close relation of the smallpox virus that the globulin sensitized against the one is equally effective against the other. Hence infection of a man with the harmless cowpox virus renders him immune against its deadly relative, the smallpox.

Great advances in understanding the mechanism of immunity reactions were recently made by Pauling and his collaborators at the California Institute of Technology. Pauling postulated that during the sensitizing of an animal against an intruder, certain chemically active groups on the surface of the intruding particle act as templates against which the globulin molecules rearrange their polypeptide chains, so as to fit

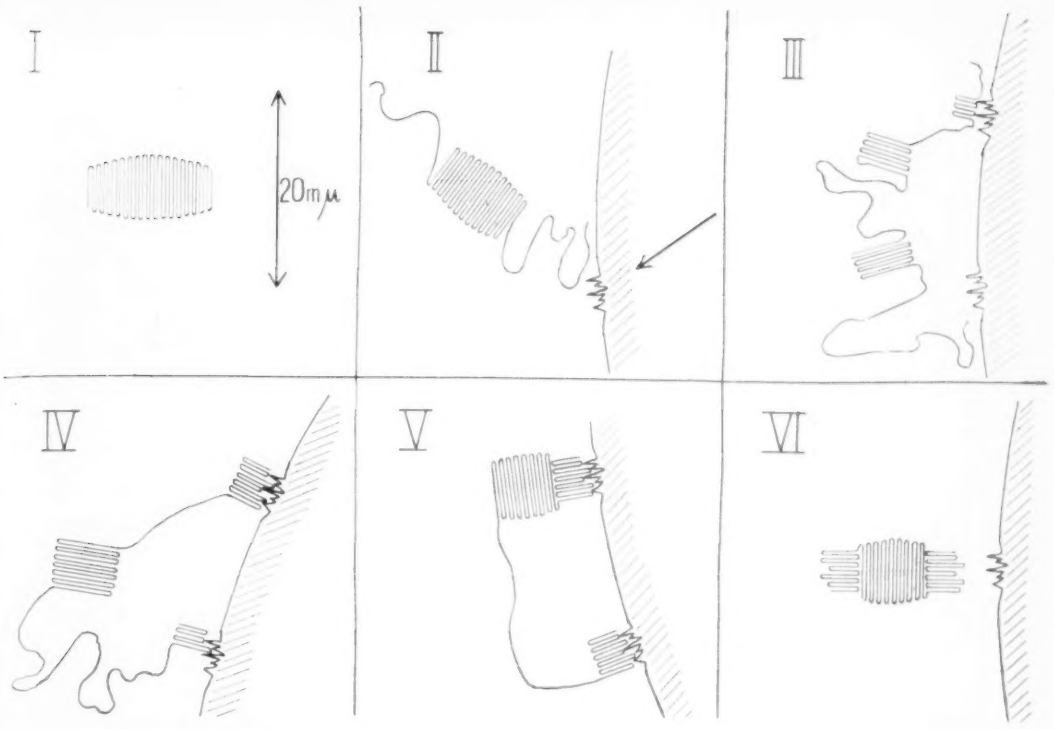


FIG. 5. THEORY OF FORMATION OF A SENSITIZED GLOBULIN MOLECULE
I, NORMALLY FOLDED GLOBULIN MOLECULE. II, MOLECULE UNFOLDS AS IT APPROACHES A PNEUMOCOCCUS. III, IV, V, FITTING ENDS OF THE MOLECULE TO ACTIVE GROUPS ON COCCUS. VI, SENSITIZED MOLECULE.

those templates as a key fits a lock. There is one qualification to be added to this picture; while only one end of a key fits a lock, both ends of a globulin molecule must adapt themselves to the templates on the intruder's surface if they are to fulfill their function effectively (Fig. 5).

Now supposing the animal has been sensitized against typhus bacilli, and those bacilli later invade its blood stream, how do the globulin molecules contrive to clot them? Each bacillus will attract hundreds of sensitized globulin molecules, which will attach themselves to its surface with one of their activated ends while trying to hook on to a second bacillus with the other. The globulins which already cling to the second bacillus will in their turn try to capture a third and so on until thousands of bacilli are clotted together in a helpless mass (Fig. 6).

Pauling followed up his ingenious theory by showing that globulin can be sensitized outside the animal's body. He prepared a solution of globulin from ox blood and let it stand at an elevated temperature together with a suspension of pneumococci, the bacilli which cause pneumonia. After several days the cocci were filtered off again. By then the globulin molecules in solution had evidently become sensitized, because experiments showed that they were now able to clot much larger numbers of pneumococci than had been contained in the original suspension.

Pauling concludes that the application of moderate heat accelerated the thermal motion of the polypeptide chains of the globulin molecules, thereby enabling them to change their configuration so as to fit onto the active groups on the surface of the pneumococci. In this way a slight change in the arrangement of the polypeptide chains transformed inactive globulin molecules into protectors against pneumonia.

Vaccination helps to reinforce the body's defence against particular diseases. Infection with many kinds of common bacteria and viruses, however, occurs almost every day, and their penetration into the blood stream in small quantities induces the pro-

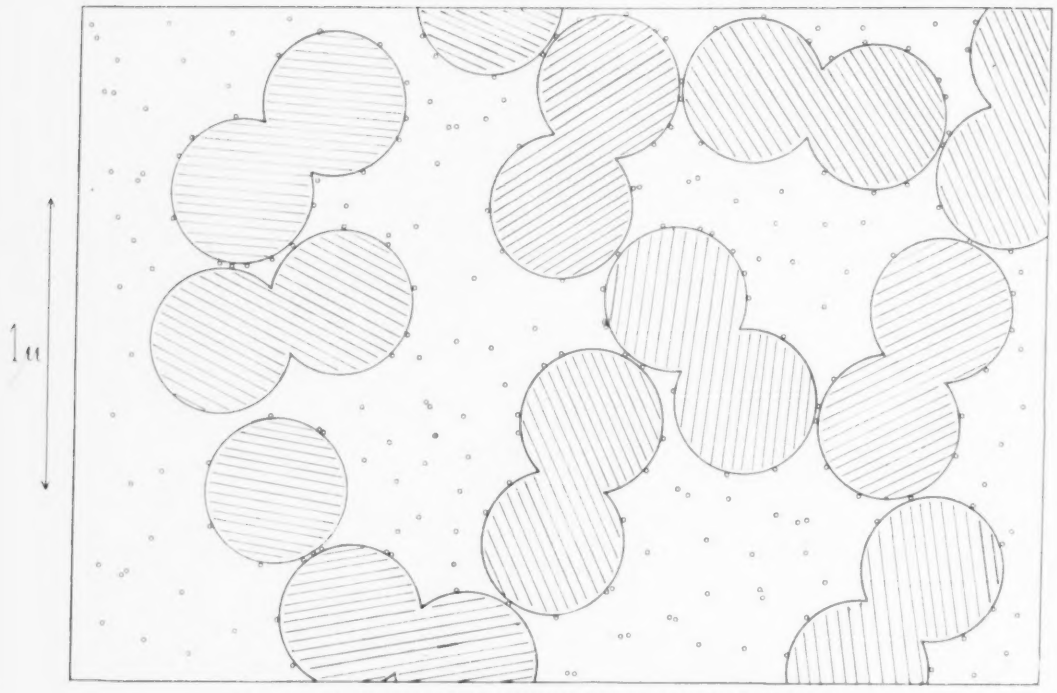


FIG. 6. CLOTTING OF PNEUMOCOCCI BY GLOBULINS
THE LARGE CROSSHATCHED BODIES REPRESENT BACTERIA; THE SMALL CIRCLES SHOW GLOBULIN MOLECULES.

duction of sensitized globulin molecules which keep the healthy organism immune against infection.

Every animal needs oxygen for the combustion of food which supplies it with energy. The combustion takes place in the tissues, and the oxygen has to come from the air. Since only one-fifth of the air consists of oxygen the organism needs some machinery to separate it from nitrogen and to transport it to the tissues. A certain amount of air reaches the tissues by diffusion through the skin and by transportation of dissolved air in the blood, but neither of these processes provides oxygen in sufficient amounts. Animals therefore have to have oxygen carriers—molecules which can combine with oxygen and set it free again wherever it is needed. In vertebrates the oxygen carriers are molecules of haemoglobin, a solution of which is enclosed in the red blood corpuscles.

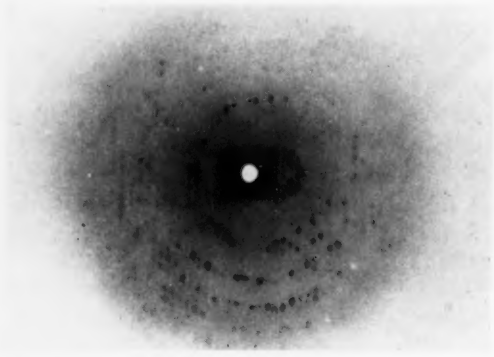


FIG. 7. X-RAY DIFFRACTION PHOTOGRAPH
OBTAINED BY THE ROTATION OF A SMALL CRYSTAL OF HAEMOGLOBIN IN A NARROW BEAM OF X-RAYS.

The haemoglobin molecule is one of the most remarkable chemical substances known. It consists of four red pigment groups known as haems and a colorless protein residue called globin. At the center of each of the four haems is an iron atom which can combine with one oxygen molecule. Thus each haemoglobin molecule can transport four molecules of oxygen.

The combination with oxygen takes place in the blood vessels which permeate the lungs from where the oxygen-rich or arterial blood is pumped to the tissues; here the oxygen is taken over by other proteins while the oxygen-free or venous blood returns to the lungs. In a test tube, shaking of a haemo-

globin solution with air produces oxygenation and turns it bright red; connection with a suction pump sets the oxygen free again and changes the color of the solution to purple.

There is nothing remarkable about that to the layman's eye. On the other hand, the chemist whose concern it is to manufacture oxygen from air cannot fail to admire Nature's ingenuity, seeing that no one ever succeeded in producing a chemical substance that can be made to combine with oxygen and give it off again by using no stronger agent than a small change in pressure.

If the chemical engineer wants to make oxygen, he has first to liquefy the air by cooling it to $-200°$ C. under high pressure and then to subject the liquid air to fractional distillation. If haemoglobin could be used instead, the horsepower required to produce one cubic foot of oxygen would be reduced to a fraction of the present requirements, in addition to the saving of much costly machinery. Unfortunately, haemoglobin, once it is removed from the animal body, is too unstable a substance to be used on a factory scale.

Haemoglobin is typical of the specificity which is so characteristic a feature of proteins. Experiments show that any change in the haemoglobin molecule, however slight, either modifies or destroys its capacity for reversible combination with oxygen. Haem by itself will not act as an oxygen carrier, nor will it do so if it is linked to any protein other than globin. If globin, on the other hand, is linked to pigments which differ from haem in nothing more than a trifling detail, it fails to transform them into oxygen carriers.

Sir Joseph Barcroft, the famous British physiologist, recently demonstrated how a slight change in its protein component can influence the oxygen affinity of the haemoglobin molecule. Experimenting on the problem of foetal respiration, he made the surprising discovery that the haemoglobins of mother and foetus are not the same.

To explain this it should perhaps be pointed out that, contrary to most people's belief, the mother's blood does not flow through the foetus. The foetus has its own circulatory system which is connected by the umbilical cord to the placenta where it terminates in a multitude of fine capillaries. There the blood of the foetus comes into close contact with the mother's blood which is pumped through the placenta in a similar but entirely separate system of capillaries.

How then does the foetus get its oxygen? Nature's solution is as ingenious as it is simple. The oxygen affinity of the foetal haemoglobin is slightly greater than that of the mother's haemoglobin, which results in the oxygen migrating through the walls of the capillaries from the blood of the mother to that of the foetus. So far as could be ascertained, the only difference between the two haemoglobins lies in their different affinities for oxygen. However, there must be a molecular cause to account for the change in behavior, and in the absence of any difference in chemical composition the explanation is likely to be found in a different folding of the polypeptide chains in the globins of mother and foetus.

Haemoglobin is generally confined to vertebrates and occurs only rarely in other animal groups. A variety of different oxygen carriers has been discovered amongst invertebrates. Snails and crabs, for instance, have blue blood. The blue color is due to an oxygen carrier which contains copper and is called haemocyanin. The great naturalist, Ray Lankester, discovered a marine worm with green blood and called its oxygen carrier chlorocruorin. Both chlorocruorin and haemocyanin are proteins, the latter having the distinction of being the largest molecule found in nature.

If the chemist wants to break down a protein into small fragments or build up a complex organic molecule, he uses high temperature and pressures, strong acids and alkalies, powerful solvents, extreme vacuum, and many other devices. The living organism has to perform the same reactions at 100° F., at atmospheric pressure, and without any solvent other than water. Instead of high pressure cylinders and fractional distillation columns, the organism uses enzymes.

Each enzyme specializes on one particular chemical reaction, which it induces without becoming either changed or used up in the process. Take pepsin, for instance, a gastric

enzyme which splits proteins into subunits of medium size; a pepsin preparation can split many times its own weight of protein without undergoing any perceptible change. Chemists call it a catalyst because it induces a chemical reaction without, apparently, taking part in it.

The variety of enzymes is baffling, as each of the many chemical reactions in nature is induced or catalyzed by an enzyme specially adapted for the purpose. There may be thousands of different enzymes, but rather less than two hundred of them are known and fewer still have been isolated and purified. All those isolated up to date are proteins and most of them are concerned either with the breaking down of food in the digestive tract of animals or with the further degradation of digested food in tissues and cells.

Little is known as yet about the class of enzymes which may one day become the most interesting one—those enzymes which induce the building up of proteins and other molecules from the small fragments which the digested food supplies.

It is highly probable that all chemical reactions which help to build a living organism are catalyzed by enzymes, many of which are still unexplored. Nor is much known about the mechanism by which these substances contrive to induce reactions. Enzyme chemistry, therefore, is still to some extent a virgin field which offers great opportunities for research, despite the impressive volume of work that has already been done.

One of the difficulties of protein research is that the molecules are too small to be observed under a microscope and yet too large for chemical analysis. This state of affairs induced scientists to develop a variety of physical methods which allow us to get a glimpse, at least, of the principal features of the molecules and to measure constants such as their weight, their shape, and their external dimensions.

The weight of protein molecules can be measured by means of the ultracentrifuge, an instrument invented in the early twenties by the Swedish scientist, Svedberg. He puts a protein solution into a small quartz cell which he then spins at the extraordinary rate of 1,000 revolutions per second. He thereby subjects the protein molecules to forces which are nearly a million times stronger than those of gravity.

Why are such tremendous forces needed to weigh protein molecules? The explanation is the same as before: they are too small to be put on a balance and too large to be weighed by the ordinary chemical methods. Svedberg's ultracentrifuge works on the principle that the weight of small particles can be calculated from their rate of sinking in water. If particles are as small as protein molecules, however, then their tendency to move hither and thither under the influence of heat counteracts their tendency to sink, so that they will remain in suspension indefinitely if they are subjected to no stronger force than the gravitation of the earth.

One way to make them sink is to spin the solution so fast that their heat motion is overcome by the powerful pull of the centrifugal field. The rate of sinking is then recorded photographically and used, together with certain other information, to calculate the molecular weight of the protein.

By making it possible for the first time to weigh protein molecules rapidly and accurately, the invention of the ultracentrifuge marked a cornerstone in protein research and has added immeasurably to our knowledge of these vital substances.

Another field of protein physics was opened up by two Cambridge scientists, Bernal and Miss Crowfoot, when they discovered that protein crystals can be made to give X-ray diffraction patterns which contain as much detail and are as clearly resolved as the patterns given by ordinary crystals such as sugar or naphthalene. It should perhaps be explained that the analysis of X-ray diffraction effects from crystals, or X-ray analysis as it is called for short, enables the physicist to work out the submicroscopic structure of matter. At the moment X-ray analysis is the most hopeful line of attack not only for measuring the external dimensions of protein molecules, but also for getting information about the distribution of matter within them.

Figure 7 shows a photograph by the writer of X-ray diffraction from a haemoglobin crystal. From pictures like this it

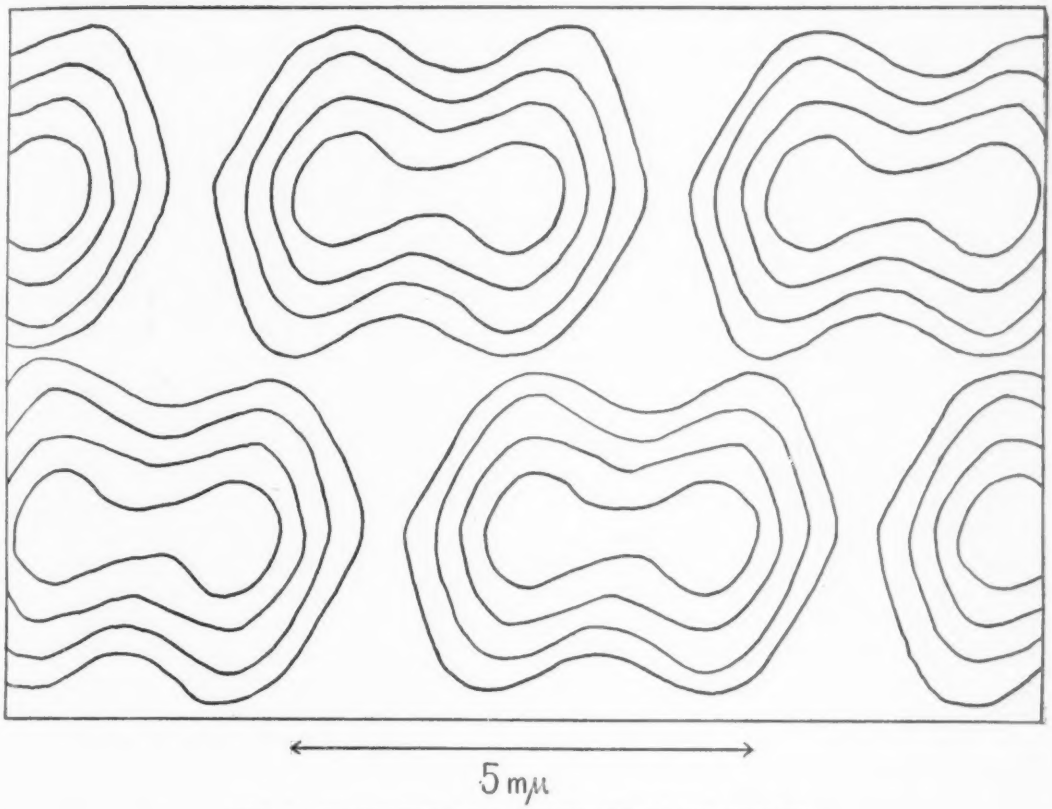


FIG. 8. CONTOURS OF HAEMOGLOBIN MOLECULES
CALCULATED FROM X-RAY ANALYSIS, THE RESULTING PICTURE IS LIKE A POORLY RESOLVED MICROSCOPIC IMAGE.

was found that the haemoglobin molecule resembles an egg-shaped body with a length of 6.4 mμ and an average width of 4.2 mμ. Figure 8 is a contour map calculated directly from an X-ray diffraction photograph and gives an end-on view of the molecules.

X-ray analysis of protein crystals was only just starting on a sufficient scale when war broke out, and many research projects were interrupted. The results so far obtained promise that it will be an important line of advance in the future.

The secret of the extraordinary versatility of proteins undoubtedly lies in their molecular architecture. Their capacity of protecting the organism from infection or of inducing chemical reactions appears to be based on the endless variety of different compositions and shapes which polypeptide chains can assume and which in turn give rise to a multitude of different patterns of chemically active groups on the surface of the protein molecules.

At present the molecular structure of the globular proteins is still unknown. While it is unlikely that any single line of research or any startling new theory will suddenly reveal all that we desire to know, a concerted effort by scientists who specialize in different fields and can attack the problem independently from more than one angle has every chance of success.

There is good hope that before very long new methods of research, together with refinements of existing experimental technique will gradually increase our general knowledge of proteins and lead to a more profound understanding of the micromechanism of Life.

PHYSICAL CHARACTERS OF THE AMERICAN NEGRO

By M. F. ASHLEY MONTAGU

THE American Negro must be regarded as one of the newest types of mankind. He represents the effect of a considerable amount of mixture among different African varieties, American Indians, and whites of every kind —principally whites of British origin. Out of this mixture has come the unique type or ethnic group represented by the American Negro. The type is even yet in process of formation, and all the evidences indicate that while the American Negro occupies, so far as his physical characters are concerned, a position intermediate between the African Negro on the one hand and the white and American Indian on the other, he will, if the social barriers against intermarriage and miscegenation are maintained, tend to stabilize around a type which is rather more Negroid than otherwise. Even so, his physical structure will continue to be characterized by many elements bearing the marks of his white and American Indian ancestry.

The chief visible characters which distinguish the Negro from the white are skin color and the character of the hair. A few other characteristics in which the Negro is popularly held to differ from the white are body odor, size of genitalia, size of brain, and vocal cords.

The results of investigations thus far carried out make possible the following summary of the physical characters of the typical American Negro. It is to be understood that the findings on the characters here cited have been repeatedly confirmed by different investigators working independently of one another, and that the results, unless otherwise stated, are statistically significant. It will be seen that in most of his characters the American Negro presents a blend of, or is intermediate between, African and white.

Compared with old American whites or mixed Europeans, the American Negro's head is slightly longer and narrower, and its height and cranial capacity are less. His hair line is lower on the forehead; his eyes are set wider apart; his nose is broader, shorter, and has a lower bridge; his jaws project further, accentuated by thicker lips; and his external ear is shorter. In body characters, the American Negro's torso is shorter, his arm longer, chest shallower, pelvis narrower and smaller, and leg longer. He is heavier in weight and shorter in stature than the white.

The American Negro's skin contains a greater amount of black pigment than that of whites. His hair is wavy, curly, frizzly, or woolly and is less thickly distributed. His sweat glands occur in greater number.

A large number of characters have been omitted from this summary; some because they have not been proved to differ in Negro and white, others because information is not available, and still others because the available evidence is so unsatisfactory that it requires separate discussion. We may now briefly consider the significance of the summarized differences.

Head. In general, the head of the American Negro is about 2 mm. longer and about 1 mm. narrower than the head of the white. Consonant with this form the elevation of the Negro head is somewhat lower than that of the white by about 5 mm. This difference in the height of the head is probably significantly associated with the very slightly smaller brain of the Negro. The mean cubic capacity of the Negro brain as compared with the white, as determined by Wingate Todd, was 1350.25 c.c. for Negro males and 1391.08 c.c. for white males. The difference is 41 c.c. in favor of white males. Cranial capacity and brain weight are characters which are very variable, and there are very few observations into which the personal factor enters so much as in the determination of these characters. But when all is said and done, Todd's difference of 41 c.c. is probably as reliable and as accurate an estimate on small samples of American Negroes and whites, of similar social status, as it would be possible to obtain. In discussing head size and brain size it is necessary to remember that the American Negro

is some 2 cm. shorter in total stature than the white; while this difference cannot account for the whole of the difference in brain size of the Negro, it probably does account for part of that difference.

It is obvious that, as far as the diameters of the head are concerned, the Negro head tends to be long as compared with the tendency towards reduction in length, and a compensatory increase in breadth and height, in the white. It is known that, within the same ethnic group, broad heads have a somewhat greater cranial capacity than long heads. Reliable evidence is lacking on the relative thickness of the bones of the Negro skull, but if there is any real difference it must be exceedingly slight, and would make, except in aged individuals, very little difference in the cranial capacity. In short, the size of the Negro head is very slightly smaller than that of the white, and different in shape, being long rather than broad. A difference of some 40 c.c. in cranial capacity suggests a very slightly smaller brain volume in the Negro as compared with the white. Actually, a difference of 40 c.c. is so small, falling well within the normal range of variation of the white brain, that it can hardly be regarded as significant from any but a purely statistical point of view.

If the Negro brain is somewhat smaller than that of the white, the difference will be found to be so little that it can hardly be considered in any way significant for the mental functioning of the Negro as compared with the white. Within the limits of normal variation, differences in brain size have about as much relation to intelligence and cultural achievement as differences in body size, and as far as the available evidence goes, that is none. The Negro Kaffirs and Amaxosa of Africa, the Japanese, American Indians, Eskimo, and Polynesians on the average have brains which are larger than those of the average white. On the same grounds as the white proclaims himself superior to the Negro, he should proclaim these peoples superior to himself—thus far, however, there are no evidences that any white man is ever likely to do so. The fact is that the external morphology of the human brain, or the characters of size and weight, have little or nothing to do with its functional capacities; these, on the other hand, must be considered as due to a complex of characters, such as the genetically determined internal (microscopic) structure of the cells and neurones, and the organization to which these are subjected by experience, the abundance of the blood vessels, the character of their walls, and the efficiency of blood drainage.

Upon these matters we have no evidence adequate enough for a definitive judgment beyond the statement that at the present time there exists no evidence in support of the popular belief that significant morphological or functional differences exist between the brain of the Negro and that of the white.

The common stereotype that the Negro's brain or mind stops growing at thirteen is completely false. The oft-repeated statement that the cranial sutures in the Negro unite earlier than do those in other races, "and thus cause a stunting of the Ethiopian intellect shortly after arriving at puberty," can now quite definitely be disposed of as a result of the fundamental studies of Todd and Lyon on suture closure in Negroes and whites; these studies prove that no significant differences in the character of suture closure exists between the two groups.

As far as the growth and development of the skull is concerned, there are no significant differences between Negroes and whites. Differences, however, do exist in the pattern and rate of growth in certain bones of the skull, and these differences are already apparent during fetal development; as Schultz has pointed out, these differences are essentially the same as those which distinguish adult whites from adult Negroes.

Thus Limson found that in Negro fetuses the back of the head was more prominent and convex, and the external protuberance on it more strongly formed than in white fetuses. Limson also found that the dental arch projects further forward, and that the anterior nasal spine is smaller in Negro than in white fetuses. These are precisely the regions of differential growth which Todd and his co-workers have shown to distinguish the adult Negro cranium; namely, a greater expansion of the occipital bone at the back of the head, and a greater forward growth of the upper jaw and dental arch. This dif-

ference in the detailed growth pattern of the jaws has been shown to hold good in Negro fetuses in respect to the premaxillary bone, which tends to lose its independence later than in the white. This fact is significantly correlated, of course, with the somewhat greater projection of the upper jaw in the Negro than in the white. This projection of the upper jaw is not a true *prognathism* similar to that which occurs in the anthropoid apes, for the early arrest in the growth of the brain case and the continued growth of the jaws and dental arches in the apes do not occur in any variety of man. The projection of the upper jaw in the Negro is accentuated, compared with the conditions in the white, because in the latter there is an earlier arrest of growth in the upper jaw than in the Negro. From every point of view the reduction in the size of the upper jaw in whites must be considered unfortunate, for the resulting restrictions of space are responsible for a very large number of disorders, such as failure of development of teeth, or the noneruption, crowding, or rotation of teeth, deflection of the nasal septum, cleft palate, and harelip. The retention of the ability for continued growth by the Negro maxilla as compared with the loss of this ability in whites would here indubitably confer a physical advantage upon the Negro.

The shape of the nose in the Negro is variable, but on the average is a shorter, flatter, and broader nose than that of the average white. It has been cogently suggested that the broad nose and larger nasal passages of the African Negro are adapted to meet the requirements of air breathed at relatively high temperatures, whereas the relatively long, narrow nose of the white is adapted to the breathing of air at relatively low temperatures. A statistical investigation of this problem gives this suggestion a high degree of probability.

Statements to the effect that the Negro nose is more primitive than that of the white are erroneous. For example, Dr. Victor Heiser has recently stated that the Philippine Negritos are true Negroes as "was shown by the one piece cartilage in their spreading noses; all other races have a split cartilage. Even the octaroons show this Negroid test of Negro blood." The fact is that no split cartilage occurs in any monkey, ape, or man, and that there are no significant characters of the nasal cartilages, except those of size, which distinguish the nose of the American Negro from that of the white. The Negro nose merely exhibits a difference in form. There is every reason to believe that the original form of the African Negro's nose persisted in Africa as an adaptively valuable character, and that in the American Negro the form of the nose, while still very variable, presents a form blending those of white, American Indian, and African Negro. The greater the admixture with whites, the more Caucasoid does the form of the nose appear. Even so, there is a marked tendency toward persistence of the broad nose. This, among other characters, has been termed an "entrenched Negro character," that is to say, a character which is said to show relatively great stability under hybridization. Other such features are lip thickness, mouth width, interpupillary distance, and ear height. As for the apparently larger eye of the Negro, this is an illusion resulting from the comparatively smaller angular orbit of the Negro. On the other hand, it has been shown that two of Todd's most dominantly entrenched Negro characters, lip thickness and breadth of nose, very readily undergo change towards the type of the white lip and nose under hybridization. It would seem, however, that an appreciable amount of admixture must usually occur before these two characters actually assume the "ideal" white form.

The slope of the forehead is not significantly different in Negroes from that in whites; its apparent difference is an illusion due to the greater projection (prognathism) of the Negro's upper jaw. The mistaken belief that Negroes have lower foreheads than whites may be attributed even more to the fact that the hair grows lower upon the forehead of the former. Under hybridization this low level of the hair line appears to be one of the first characters to yield.

In African Negroes the chin prominence is not as marked as in whites, but in American Negroes it is intermediate between the condition found in African and white. Undoubtedly it increases with increase in the proportion of white admixture.

Body. Since statements are frequently made which refer to the alleged "apelike" hands of the Negro and his long arms or long legs—as those who make such statements see fit—we may briefy consider these matters here.

The Negro torso is about an inch and a quarter shorter than that of the white, the Negro leg a little less than an inch and a quarter longer. The Negro arm is about an inch longer, the upper arm being relatively shorter and the forearm relatively longer than in the white. As for hand breadth and length, Todd and Lindala found no significant differences in these dimensions, a fact which led these investigators to remark, "It is rather astonishing to find that the 'long narrow hand' of the Negro vanishes on the average." It was considered by these authors that this finding could not be imputed to admixture with whites, since their series gave many evidences of relative purity of strain. Herskovits also failed to find any significant difference in the width of Negro and white hands. While the Negro hand as a whole is not longer than the white's, the fingers appear to be longer. Thus Herskovits found that the middle finger is longer in Negroes than in whites. This, then, would make that portion of the hand in the Negro which extends from the wrist to the base of the fingers shorter than in the white, but this supposition requires confirmation. With respect to the length of the thumb, the present writer has found that the African Negro thumb is about 1.7 mm. shorter in relation to the length of the middle finger than the relative thumb length of the average Englishman. These findings corroborate, in a rather striking manner, the observations of Schultz who found the length of the thumb in relation to the middle finger in adult Negroes to be 1.8 mm. less than in adult whites. In relation to the length of the hand Schultz found that both in Negro fetuses and in adults the thumb was relatively shorter than in whites.

Hence, as far as the upper extremity is concerned, it would appear that every part of it is perfectly proportionate to the other, and that the greater length of the Negro arm may be interpreted as a compensatory adjustment in relation to the shorter torso. As for "apelike" characters of Negro hand or arm, these are entirely lacking, both in the proportions and in the deeper structures.

Unlike the bones of the arms, those of the legs of Negroes are proportionately the same as those of whites, the length of the whole leg being greater. As Todd has put it, "The long shin of the Negro is an illusion of its circumference, as his long foot is an illusion of its flatness." In length and breadth the Negro foot shows no significant differences from the foot of whites, these dimensions being entirely proportional to leg length.

Recent attempts to show that Negro athletes enjoy an unfair advantage over white athletes, owing to the alleged possession of a longer heel bone and longer calf muscles, have been critically examined by W. M. Cobb, who has shown that many of the outstanding Negro athletes have legs and feet which are predominantly white in their characters, and that Negroid physical characters are not in any way significantly associated with Negro athletic ability. In this connection it may be noted that Malafa, in an investigation of the bodily characters of sprinters and nonathletes, carried out on 100 white students from the Grammar Schools of Brno, Czecho-Slovakia, found that long legs were one of the principal characters which distinguish the athletes from the nonathletes. This character constitutes, of course, a selective factor and is not correlated with racial or ethnic characters.

One fact more concerning the Negro foot: the alleged longer heel bone is nonexistent, but both in fetuses and adults it is given an appearance of greater length by a thick layer of subcutaneous fat.

Pelvis. It is frequently stated that the Negro pelvis differs from that of the white in being longer and narrower. This statement is not quite true. The Negro pelvis is smaller in all its dimensions. It is greatly to be doubted whether there is any truth in the common belief that because the Negro female has a narrower pelvis than the white female she is the more likely to experience a less satisfactory termination of a pregnancy produced by a white than by a Negro male; the suggestion here usually being that the rounder-headed white is likely to produce a fetus which will have a larger and a

rounder head than can be safely delivered through a small, narrow pelvis "intended" for the delivery of Negro-fathered children.

Caldwell and Moloy, from the obstetrical point of view, have investigated the anthropometric characters of the pelvis of Negro and white females. These investigators find that female pelves may be classified into three types, as follows: (a) the gynecoid, or average female type, which occurs in 42 per cent of Negro and in the same percentage of white females; (b) the android type, more closely approximating the male than the female pelvis, which occurs in 15.7 per cent of Negro females and 32.5 per cent of white females; and (c) the anthropoid type with a long antero-posterior diameter and a relatively narrow transverse diameter, occurring in 40.5 per cent of Negroes, and slightly less than half that percentage in whites.

Obstetrically, the most dangerous form of the pelvis is the android type which occurs with double the frequency among whites that it does among Negroes. The other two types of pelvis present no especial obstetrical difficulties. It therefore seems most improbable that the form of the pelvis plays a more significant role in childbirth in Negroes than in whites.

Davenport and Steggerda "entertain the hypothesis that, in the case of the Black woman who carried a mulatto child *in utero*, her narrow pelvic outlet and the child's large head might offer an important disharmony." In order to test this hypothesis they proceeded to examine the heads of newborn colored and white children. They found that the heads of newborn colored infants were slightly smaller at birth than those of white newborn infants, and it is quite evident from their findings that no disharmonies between pelvic outlet and shape of the head occurred in the Jamaican series examined by them. Data on the pelves were not available to Davenport and Steggerda, but the data which have since appeared render highly improbable a significant disharmony of the kind hypothecated.

Skin color. Skin color is a very complex character and depends upon a multiplicity of factors for its expression. As is well known, every color from black to white occurs among American Negroes. The greater the admixture of white genes, the lighter, as a rule, does the skin appear. It has been found that in the American Negro the percentage of pigmentation increases fairly rapidly until puberty, reaching its maximum at about the age of 15; thereafter it decreases rapidly until about the age of 35 and then decreases very slowly during the remainder of life.

The inheritance of skin color is a cumulative process involving the operation of multiple factors, the individual having the largest number of factors usually showing the character developed to the highest degree. In Negro-white crosses the genes for black pigment are incompletely dominant over those for lighter color, and the first generation is mulatto or intermediate in shade. The offspring of mulattoes, however, exhibit a great variability and gradation of their skin color, from black to white. This is an effect of multiple-factor inheritance, for owing to the large number of factors now present, they are segregated in combinations which are more distributively variable than those that were possible in the original ancestors. This form of blending inheritance is essentially Mendelian. The evidence thus far suggests that there are several pairs of genes conditioning skin color, yielding about a score of genotypes and about ten phenotypes—assuming that the gene pairs have approximately the same effect. Actually a far wider range of phenotypes is observed, suggesting the existence of other modifying genes affecting skin color. Further investigations of a most refined and laborious nature remain to be carried out before the mechanism of the inheritance of skin color is fully understood.

Black children cannot be born to parents one of whom is "pure" white. When a colored infant is born to white parents it is proof positive that both of the parents carry Negro genes. Similarly a Negress with some white genes cannot bear a white child to a "pure" Negro.

Hair. The hair of Negroes is dominantly black, although it may be dark brown, gray brown, light brown, and even red in varying frequencies, the lighter colors occur-

ring more commonly among persons with a half or more of white ancestry. The black color of the hair is one of the most dominantly entrenched of Negro features. On the other hand, hair form is, interestingly enough, one of the most easily modifiable of characters; and while among American Negroes every form of hair from woolly to straight is to be found in a considerable number of gradations, it is clear that under hybridization hair form yields most readily to the influence of new genes. This fact was strikingly brought out in the classic study of Fischer on the hybrids of Hottentot-Dutch ancestry in South Africa; the one group with dominantly woolly hair, and the other with dominantly straight hair. Fischer found that among these Rehobother Bastards woolly hair occurred in 29 per cent, frizzly or wavy hair in 49 per cent, and straight in 22 per cent.

Davenport and Steggerda found that among Jamaicans woolly hair occurred in 100 per cent of blacks, in 86.7 per cent of browns, and 1 per cent of whites. Curly hair occurred in none of the blacks, in 11.4 per cent of browns, and in 30 per cent of whites. Wavy hair did not occur in blacks, but was found in 2 per cent of browns and 30 per cent of whites; and 39.2 per cent of the whites had straight hair.

Hair form in Negro-white crosses varies with degree of admixture. The evidence indicates that distinctively Negroid forms of hair, such as frizzly and woolly, do not appear unless there is at least three-eighths of Negro ancestry in the individual.

The inheritance of hair form in Negro-white crosses has been studied by Davenport, who found that straight hair is a recessive condition. Wavy or curly hair is a heterozygous condition, so that wavy × wavy yields offspring which is straight, wavy, and curly in the proportion 1:2:1. Curly × curly yields mostly curly; yet 14 per cent of the offspring show straight hair. So it is apparent that some curly-haired parents carry the gene for straight hair as a recessive.

Straight × wavy and straight × curly produce a good many curly offspring. Thus, an analysis of hair form of 428 offspring of Negro-white crosses showed that seventy-five had curlier hair than the more curly parent, while only forty-three had straighter hair than the straighter parent, thus suggesting the general dominance of the curlier condition.

Distribution of hair. It is a common belief that the Negro is less hairy than whites. This belief is well-founded, for the development of his body hair, both in thickness and in distribution, is considerably less than in the white. Recent investigations suggest that a reduction in the number of hair follicles has occurred in the Negro, and also a deficiency in the growth of individual hairs. This would appear to be the most plausible explanation of the relative glabrousness of the American Negro. Investigation of the facial hair of Negroes and whites reveal that there is no difference in the actual number of hairs, but that the average thickness of the facial hairs in the Negro is less than that in the white; also the hairs of Negro women are somewhat shorter than those of white women.

In the Negro, as compared with the white, the general tendency towards reduction in the amount and distribution of hair has proceeded furthest, as is evidenced by the reduction in the number of hair follicles on the fingers and toes, and the arms and hands of Negroes. It is highly probable that the genetic mechanisms here operative are much the same as for skin color and hair form, with the presence of multiple factors and the consequent segregation of intermediate forms.

Sweat glands and body odor. One of the most popularly entrenched beliefs concerning the Negro is that he possesses a unique and particularly objectionable body odor. This odor depends upon a very large number of factors. Human sweat consists of the secretions of the sebaceous glands and the sweat glands proper. Among the known constituents of sweat are water, sodium chloride, phosphates of the alkaline earths, urea, creatinine, ethereal sulphates of phenol and skatoxyl, neutral fat, fatty acids, cholesterol, albumin, and iron. Depending upon the amount of these substances present, the odor of the sweat will vary in the same individual from time to time, and under different environmental and dietary conditions.

Upon this subject no really adequate studies have been made. We now know only that body odor varies from individual to individual within the same ethnic group, and that members of different ethnic groups, and even castes or classes, find the odor of members of other ethnic groups and castes or classes distinctly different and frequently objectionable. Klineberg refers to:

> An experimental attempt to throw a little further light on this question . . . in an unpublished study by Lawrence, who collected in test tubes a little of the perspiration of White and Colored students who had just been exercising violently in the gymnasium. These test tubes were then given to a number of White subjects with instructions to rank them in order of pleasantness. The results showed no consistent preference for the White samples; the test tube considered the most pleasant and the one considered the most unpleasant were both taken from Whites.

Klineberg concludes:

> There may be racial differences in body odors, but it is important first to rule out the factors referred to above, particularly the factor of diet, before a final conclusion is reached. It is obvious that cleanliness is also a factor of importance. In any case, the phenomenon of adaptation enters to remove any special unpleasantness arising from the presence of a strange group.

Comparative studies of the physiology and chemistry of the sweat of Negroes and whites do not exist, but several studies have been made of the sweat glands in Negroes and whites from the anatomical standpoint. Clark and Lhamon found that the hands and feet of Negroes were more abundantly supplied with exocrine glands (glands which originate from the skin) than were those of whites. Glaser, in an investigation of the sweat glands in one Bantu Negro and in one European, found that "the regional distribution of the sweat glands in the Negro agrees closely with that usually given for the European. . . . In the great majority of regions compared, however, the Bantu has more sweat glands than the European, and this is probably of considerable value to him in resisting extremes of heat." Homma, in a study of the apocrine glands (glands which originate from a hair follicle) of ten Negroes and twelve whites, found that they occurred three times more frequently in the Negroes than in the whites, and that while such glands never occurred in the breasts of whites they were sometimes to be found in the breasts of the Negroes.

Thus, it is evident that if Negroes possess a greater number of sweat glands than whites, heat regulation under high temperatures would be more efficiently performed in them than in whites; and it is also possible that if there is any difference in the odor of their sweat, it probably represents not a difference in kind, but in degree or intensity, owing to the cumulative action of the number of glands involved.

Blood. The belief that Negro blood differs from white blood is another common stereotype. Here, again, there is no ground for the belief whatsoever. In all the constituents of the blood, such as hemoglobin, red cells, agglutinogens, and agglutinins, the blood of Negroes is the same as that of whites. The same blood groups A, B, AB, O, and the blood types N and M and the Rhesus factor occur among Negroes as among whites, so that transfusions of blood from Negroes to whites, and vice versa, are perfectly safe in every way. As would be expected, the only differences found are in the distribution of the frequencies with which the various blood groups occur in Negro and white.

Even when these facts are understood, objections are sometimes raised to the effect that the transfusion of Negro blood into a white might make the white somewhat Negroid. This is, of course, sheer nonsense and merely reflects the persistence of the age-old superstition that the blood is the carrier of the hereditary traits of the individual, and that the latter are transmitted by blood. This is not so. Blood is the nutritive material of the body, through the medium of which many other substances are conveyed to the tissues, but none of these when injected into another individual are in the slightest degree capable of altering his hereditary or physical traits. It is highly desirable that the term "blood" as a synonym for "heredity," "ancestry," or "race" be completely eliminated from common, as it has been from scientific, usage.

INTERDEPENDENCE IN PLANT AND ANIMAL EVOLUTION*

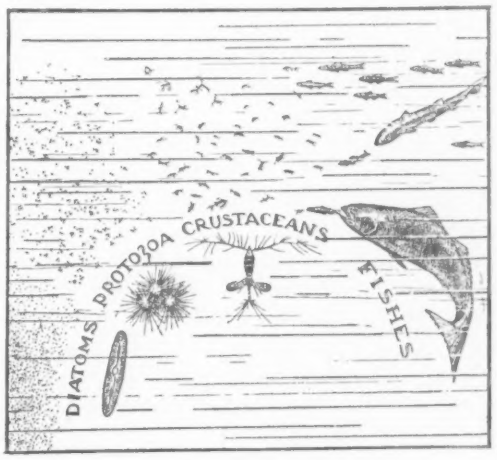
By ALFRED GUNDERSEN and GEORGE T. HASTINGS

THAT animals depend on plants for their food is well known, but this is only part of the story. In the course of its evolution the plant world has greatly influenced the animal world, and, vice versa, the animal world has influenced the plant world in a number of important respects. The extensive subjects of plant and animal evolution are naturally taken up separately, but there are clearly vital connections between them. We have attempted to call attention briefly to what we believe to be varied aspects of one comprehensive whole.

ALGAE AND FISHES

Algae, protozoa, copepods, and fishes form the principal food chain of the ocean. Sea environment is more nearly uniform than land environment. In the water everything weighs less, temperatures are more even, and there can be no water shortage as there often is on land. As a result of this uniformity, water life is less diversified than land life. Fringing continents and islands nearly everywhere is a zone of seaweeds, mostly brown in cold and temperate climates, mostly red in warm climates and at greater depths. In this shore zone sea life is the most varied and abundant, attached to the bottom, creeping, floating, or swimming. In the middle of the oceans organisms must be floating or swimming. The conditions of the open sea, in particular the conditions at the time of storms, are such as to require plant life to be of very small size and very strongly built. Such are the characteristics of the innumerable diatoms, the primary food supply of the sea, the "grass" of the ocean.

Diatoms are one-celled algae, enclosed in two valves, one fitting over the other like the lid on a box. There are thousands of species, many of great beauty, with symmetrical designs on their valves. They grow and multiply rapidly in sunlight a few feet below the surface of the water, and as a result of their photosynthesis vast quantities of oxygen are given off. Diatoms average less than one two-hundredths of an inch in diameter; their numbers are enormous. They furnish food for the slightly larger but less numerous protozoa. Therefore the size and the number of diatoms must influence the size and number of protozoa. A very abundant form of protozoa is *Globigerina*, one of the foraminifera, whose tiny "skeletons," like the myriads of diatom "shells," have settled to make great deposits on the ocean bottom.



FOOD CHAIN OF THE SEA[1]

Both diatoms and protozoa are eaten by the slender and numerous crustaceans, the copepods. One copepod has been estimated to eat 100,000 diatoms in a day. The balance between plant and animal populations is a constantly shifting one. Nearly all young fish live on the small crustaceans. A herring, the most abundant fish in the ocean, takes thousands for a meal. In turn the herring may be eaten by cod, often a half dozen herring being found in the stomach of one codfish. They are also eaten by mackerel and other fish and by sea gulls. In the oceans of the tropics, heat-loving bacteria reduce the number of diatoms, and, as a re-

* Brooklyn Botanic Garden Contributions, No. 101.

[1] All sketches by Maud H. Purdy.

sult, the fish population there is reduced. The variation in the number of young fish in different years probably depends largely on the spring appearance of diatoms at the time of the hatching of fish eggs. An interval between the time the tiny young fish need food and the appearance of diatoms must result in great mortality among the fish.

Facts of structure and of development of living forms suggest that land life was preceded by water life. This is confirmed by fossils from the early periods: the Pre-cambrian, Cambrian, and Ordovician included only water forms, such as algae, foraminifera, sponges, corals, echinoderms, mollusks, and trilobites.

Diatom deposits are abundant from the Triassic to the present. For example, forty feet of diatom shells underlie Richmond, Virginia. What plants were in the sea before that time? Were there diatom ancestors without shells and less abundant? The teleosts or modern bony fishes began in the Jurassic with the great sea reptiles. Possibly the earlier sharks and ganoid fishes were present in only relatively small numbers. In Cenozoic times mammals came into the sea: whales, seals, walrus, and manatees.

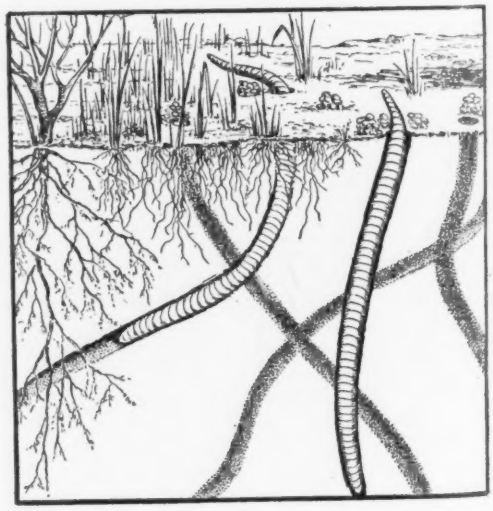
It is suggestive that the sequence of fossils of long ago, algae and protozoa preceding arthropods and these preceding vertebrates, is also the sequence of the food chain of today. Food had to come first: only then could come the successive groups of animals in definite order. In the sea we have dependence on diatoms rather than interdependence. Without the animals, the diatoms need not be different; without the diatoms, the animals could not exist.

Roots and Worms

Soil life seems to be in various ways intermediate between water life and land life. For example, the group of fishes called dipnoi live partly in mud but are to some extent adapted to land life. Land plants and land vertebrates appeared about Silurian times, perhaps four hundred million years ago. Algae most likely were the first plants also on land. Lichens, also probably very early land plants, are a good example of vital interdependence between algae and fungi. Lichens, liverworts, and the fossil *Rhynia* may suggest different lines of development of very early land plants. They are all of small size, like algae they take little or no material from the substratum, and they have no true roots.

But roots characterize all larger plants like ferns and seed-bearing plants. They require soil containing some degree of moisture, in the case of some desert plants growing down fifty feet to get it. Roots usually have many slender branches, covered with myriads of root hairs. These root hairs, constantly renewed, enable plants to take up water and mineral solutions in quantity. Soil is composed of minute fragments of rocks, usually surrounded by films of water and air pockets. There is also organic material, humus, which is important for retaining moisture. In the case of large plants, roots have also the important function of anchoring them securely.

Many animals, especially earthworms, influence the character of the soil. These worms are almost universally distributed, except in deserts; also there are none on oceanic islands, since they are intolerant of salt water. They respond to changes in moisture, in temperature, and in organic content of the soil. Earthworms eat soil particles, digest the organic matter, and deposit the remainder near their holes, with the result that in the long run the soil is



ROOTS AND WORMS IN THE SOIL

changed physically and chemically and becomes better adapted to support vegetation.

Gilbert White wrote in 1777, "A good monography about worms would open up a large and new field in natural history. . . . Vegetation would proceed but lamely without them." About a century later Darwin wrote, "the plow is one of the most ancient and valuable of man's inventions, but long before he existed the land was in fact regularly plowed, and still continues to be plowed by earthworms. It may be doubted whether there are many other animals which have played such an important part in the history of the world as these lowly organized creatures." Different and much smaller worms, the nematodes, are extremely abundant and to some extent supplement the function of earthworms, except that their food is mostly the underground parts of living plants.

Many eggs of insects are laid and hatched underground. Larvae are, so to speak, the worm stage of insects, and feed largely on roots. In some cases, as the Japanese beetle, the feeding of larvae on roots causes wide destruction. Ants and beetles, in particular carrion beetles, and, in tropical climates, termites, have important parts in soil making. Rodents, moles, and other animals make underground burrows for safety and for winter protection. Among plants, fungi and bacteria take essential parts in maintaining soil fertility. All soil organisms contribute to the organic content and to the mixing of the soil. Their excrements and ultimately their dead bodies became part of it. Thus, with exceptions, the soil activities of animals are beneficial to plants and have influenced their growth and development to an extent not generally realized.

Earthworms are Oligochaeta or few-bristle worms and are not known as fossils, but their relatives, the Polychaeta or many-bristle marine-worms, have early fossil representation. So we believe that earthworms or their relatives have been active since early times.

Cycads and Reptiles

Cycads and reptiles, or more specifically cycadeoids and dinosaurs, were the most abundant plants and animals during a large part of the Mesozoic era. Both groups were forerunners of important succeeding ones. Ginkgo and conifers were larger than cycadeoids, but less common. Fleshy seeds such as those of cycads and ginkgo imply adaptation to animals; they long preceded fleshy fruits. Some of the dinosaurs doubtless had a part in the distribution of Mesozoic seeds.

Marine iguanas feeding on seaweeds show that reptiles can live on primitive plant food. The quiescence of reptiles as compared with the activity of mammals suggests that their food requirements are smaller. As flowering plants are not definitely known before the Cretaceous period, their distribution before that time is likely to have been limited. Gymnosperms and more primitive plants, including water plants and sea vegetation, must have supplied the basic food requirements of early Mesozoic times.

All seed-bearing plants have two sizes of spores and the small spore must in some way be brought to the large spore; that is, pollination must occur. Living gymnosperms (cycads, conifers, and their relatives) are all wind-pollinated, and there is no reason to suppose that extinct gymnosperms (seed ferns, cordaites, and cycadeoids) differed in this respect. Wind-pollination is effective where many plants of one kind are somewhat near together, so that they present a fairly large surface for the wind-blown pollen. This is the case usually with conifer forests, with poplars and birches in the north, and

SEAWEED, FOOD OF MARINE IGUANAS

with oaks and hickories in middle temperate regions. In the tropics, where we now have a very great variety of species, wind-pollination is not effective. It requires the activity of an insect to bring pollen from one flower to a similar one some distance away.

The cycadeoids had one character different from other gymnosperms; namely, small and large spores on the same cone. In this they were like flowering plants, but their carpels were still open. One step more and they would have had flowers.

In the warm and moist Carboniferous period there were many thousands of species of plants and animals. From the succeeding cold Permian period only a few hundred species are known. In the milder Triassic period the early dinosaurs were few and small. In the Jurassic came the very large Brontosaurus and Diplodocus, living half submerged. The teeth and the claws of the dinosaurs sharply differentiate the many herbivorous from the relatively few carnivorous kinds.

During the Cretaceous period the relative importance of the great groups of plants changed; cycads began to decline in numbers and kinds and have continued to decrease so that today but a small remnant survive. At the same time flowering plants increased until by the end of the period the tree and shrub flora was not greatly dissimilar from that of today. The variety of plants resulted in variety of food and a great increase in the kinds of dinosaurs. But towards the close of the period dinosaurs began to decrease and ended in total disappearance. According to Barnum Brown, "Plant-eating dinosaurs were restricted in their feeding habits to certain types of vegetation. When, through regional elevation towards the close of the Cretaceous period, lakes and swamps were drained, and plant-life changed or became scarce, plant-eaters died out locally and the carnivores went with them." It has also been suggested that the extinction of dinosaurs may have been connected with the spread of the smaller but more intelligent mammals.

Flowers and Insects

Flowers and insects furnish the best known example of plant and animal interdependence. Koelreuter, Sprengel, Darwin, and Hermann Müller studied pollination. Sprengel's famous "The Secret of Nature in the Form and Fertilization of Flowers Discovered" was published in 1793. Gymnosperms are all wind-pollinated and there is no reason to think there was any other kind of pollination up to the coming of flowering plants. A number of the flowering plants also are wind-pollinated, such as the plane tree, sweet gum, elm, oak, walnut, and poplar and, among herbaceous plants, all grasses, sedges, and rushes. Plants pollinated by wind produce pollen in very large quantities, while they have relatively few ovules. Wind-pollination requires a large amount of pollen because so much is blown away and never reaches its destination. Individual wind-pollinated flowers are usually small, inconspicuous, odorless, and nectarless, with pollen and ovules in separate flowers. Living cycads are dioecious; conifers are mostly monoecious. Among wind-pollinated flowering plants staminate flowers are often in pendulous catkins, adapted to sway in the wind, while pistillate flowers have broad lobed or feathery stigmas.

Cycadeoids had dicotyledonous embryos and in most cases stamens and carpels on the same cone. Such presence of stamens and ovules near together would be a prerequisite for insect fertilization; if they were

POLLINATION BY BEES AND BUTTERFLIES

apart, insects would not go from one to the other and the needed cross-fertilization would not be effected. According to Arber and Parkin's widely accepted theory of the origin of flowering plants, following Wieland's discoveries, angiospermy is a method of protecting ovules from insect visitors. They suggest that the broad angiosperm leaf came much later than the angiosperm flower. Magnolia, morphologically the most primitive angiosperm, is the nearest to the cycadeoids. Today we see that beetles crawl on gymnosperms and eat pollen; long ago insects doubtless were eating cycadeoid pollen; the first cross-pollination by insects would be incidental and occasional.

Magnolia flowers are large, single, open, regular, with flower parts separate, with abundant pollen, without nectar, color in part white, greenish-white, or yellowish. Such are believed to be the characteristics of primitive flowers. It is probable that wind-pollinated trees, such as birch, oak, and walnut, formerly had separate carpels, making them in this respect more like magnolia. Advanced flower structures are the opposite of those mentioned: small flowers, in dense inflorescences, carpels united into a pistil, petals united into a sympetalous, irregular corolla. The more specialized a flower the fewer the species of insects that visit it. In a few cases an insect is adapted for only a single species of flower.

Stages of adaptation of insects to flower visits are believed to have been somewhat as follows: (1) Insects largely with biting mouth parts, lacking structures adapting them to flower visits, but which occasionally visit flowers: dragonflies, grasshoppers, many flies, and beetles. In this connection it is of interest that Carboniferous insects were morphologically unsuited for entering flowers. (2) Insects partly adapted to flower visits: short tongued bees and some flies. (3) Fully adapted flower visitors, with both structure and habits aiding them in getting nectar, while at the same time they effect cross-pollination: long-tongued bees, butterflies, and hawk-moths. Corresponding to this group is the very large variety of flower adaptations which can only be explained in connection with their insect pollination. In addition, some insects cause definite injury to flowers: ants, aphids, bugs, many beetles, and the caterpillar stage of many moths and butterflies.

As we see today that food and food selection plays such an important part in the lives of insects, it is natural to believe that their evolution has been influenced by past changes in food or ways of getting it. Trilobites lived through the early geological periods and vanished. But we have their myriad relatives: copepods in the sea, insects on land. "Bees have played the chief part in the evolution of flowers," wrote Hermann Müller in 1873. And we cannot doubt that flowers have played a large part in the evolution of bees and other insects.

Angiosperms and Birds

Long ago a small number of primitive birds were able to live among a vegetation of cycads and conifers. But today broad-leaved forest trees, fruiting shrubs and herbs, and multitudes of birds belong together. The broad leaves and more succulent shoots of flowering plants, and especially their fruits, make them far better sources of food than gymnosperms. Flowers, by their fragrance and color, announce to insects when they are ready to have their pollen transferred; similarly fruits, by their fragrance and changing color, announce to birds and

BIRDS FEEDING ON SEEDS AND FRUITS

other animals when they are ready to have their seeds transported. Numerous fruits have been greatly changed by human selection. But before man was on the scene, birds and other animals had food preferences, and the fruits selected by them were gradually changed and had the best chance of being distributed and thus of survival. Birds, if they have abundant food, eat what they prefer, otherwise what they can get. They eat both dry and fleshy seeds and fruits, as well as vast numbers of insects. Birds' bills suggest the nature of their principal food: finches, which eat hard seeds, have heavy conical bills, fruit-eaters, such as orioles, have sharp pointed bills. In the cross-bills the tips of the bills are effective for extracting seeds from cones. Seeking larvae, the woodpecker uses its bill to bore holes in bark, while large birds of prey, wading and swimming birds, and insect-feeders, such as swallows, all have bills adapted to their kind of food.

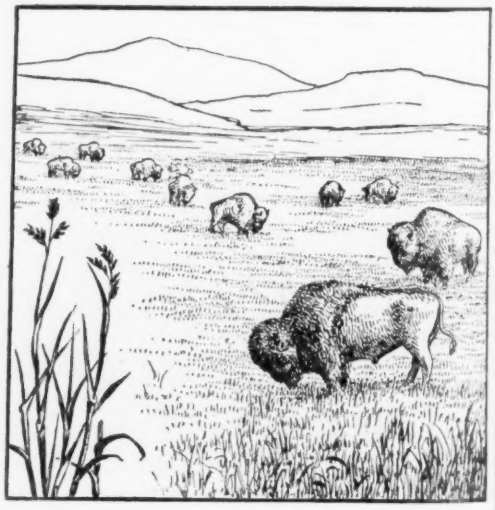
Numerous seeds pass unharmed through the alimentary canal of birds, which are the most effective of all animals in the long distance distribution of seeds. With the increase and spread of flowering plants in the Cretaceous period, the food supply for animals was greatly increased. At the same time birds perfected their powers of flight and took a greater part in seed distribution. More angiosperms, more insects, more birds. But birds probably did not assume anything like their present importance until Cenozoic times. Plants also play an important part in bird life by providing shelter. Nearly all use plant material in building nests. Most small birds nest in trees and bushes, while many ground-nesting birds conceal their nests in clumps of grass or in low bushes. Small birds find safety among foliage where large birds cannot follow.

Carboniferous trees had no annual rings, implying an even climate. In trees of the Cretaceous period annual rings and deciduous leaves indicate a climate with seasons. Warm blood was at first probably an adaptation to winter seasons, beginning some time in the Mesozoic. Birds and mammals carry, so to speak, summer climate inside their feathers and furs. Warm blood is closely connected with more heart chambers, more effective blood circulation, greater activity, and greater need of food.

Fossil records indicate that one branch of reptiles developed into birds, another branch into mammals. The "living fossil," the Australian duckbill, is intermediate between birds and mammals. Both groups were probably tree-living at first. The first birds could fly very little; the first mammals were very small. The earliest known bird is the famous Archaeopteryx from the Jurassic period in Bavaria. Because it had feathers and wings, it was a bird, but it must have been a poor flyer. It had claws on the wings, teeth in sockets, and a long tail with vertebrae to the tip; these were its inheritance from reptilian days. From their teeth it has been supposed that these and Cretaceous birds lived largely on fish, but it would seem reasonable that the tree-living ancestors of birds, like those of mammals, were insectivorous and also used the seeds of cycadeoids and other plant food.

Grasses and Herbivora

Grasses are the main food of the herbivorous animals. Grasslands cover large areas of the earth, but where moisture and heat are sufficient, forests grow. In the temperate zone rainfall is slight in the interior of continents; these regions are too dry for forests. Grasses cover the extensive, nearly level regions called prairies in North America.



BUFFALOES FEEDING ON GRASSES

llanos in South America, steppes in Russia and Asia. Grasses were long believed to be primitive angiosperms, but are now more generally considered as a specialized group. Monocotyledons, such as lilies, rushes, and sedges, have typically three-parted flowers, which was doubtless the ancestral type of flower of Monocotyledons. Among the grasses, bamboos have a three-parted perianth with six or more stamens: most other grasses have a much reduced two-parted perianth with only three stamens. The early grasses were probably tall forest plants somewhat like bamboos, adapted to a warm and moist climate. The conditions of prairie life are very different; here entirely different and more specialized grasses thrive.

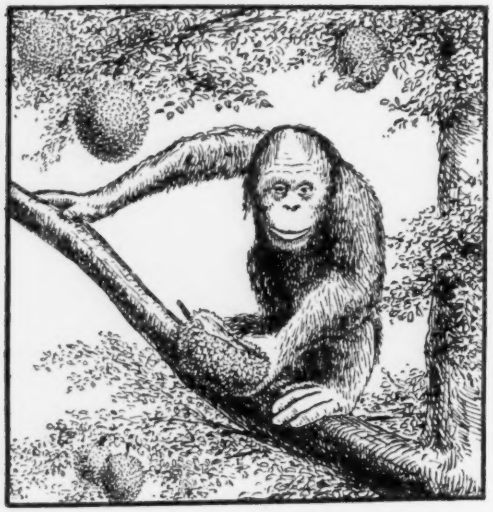
Plants generally grow at the end of the stem and its branches. Grass leaves consist of a sheath at the base and a narrow blade; their growth is not at the tip but near the sheath. Cutting with a lawnmower has a tendency to eliminate plants other than grasses; grazing by herbivora has a similar effect. Grasses are adapted to having their leaves cut off, while other plants are not. Continued cropping causes no injury to grasses, rather it stimulates their growth, and at the same time they are fertilized by the resultant animal dung. Grazing animals by their specialized teeth and digestive system are adapted to feeding on grasses. It is as if grasses and herbivora, through long periods, gradually became adjusted to each other; the same as flowers and insects. A few started it; they had an advantage, and many followed. When the growth of grasses is ended by cold or dry weather, grass leaves dry from the tip; they become hay and so can continue to feed herbivora. Persistent dense leaves and roots of grasses form the characteristic sod, unfavorable to the growth of other plants. Spreading by roots, or tillering, is a mode of reproduction of grasses which is aided by the hoofs of ungulates. The small seeds of grasses are readily transported by the wind.

So long as dinosaurs dominated, ground mammals had little chance to spread. Berry has pointed out that with increase of flowering plants there would naturally be an increase in the number of insects and an increase in the number of primitive insectivorous mammals. About the same time as, or shortly after, the extinction of dinosaurs, mammals acquired an important structural improvement, beyond the marsupial stage, in the development of a placenta, which enabled the young to grow more fully before birth. With abundant food from flowering plants, placental mammals rapidly evolved along varied lines into tree-living, herbivorous, carnivorous, and aquatic groups.

The forest-dwelling ancestors of ungulates showed little indication of what their descendants would become. They developed along two lines, the odd-toed from which came our horses and their relatives, and the much larger even-toed group that developed deer, antelopes, sheep, and cattle. By the end of the Eocene period the principal large groups of mammals were in existence. In several cases the fossil history is very complete; for example, those of horses and elephants. In the Eocene the ancestors of these two groups were not very different, both about the size of a fox. Both lines gradually increased in size, some side lines leaving no descendants. The small ancestral horses had simple teeth; they were adapted to browsing in woodlands and groves rather than to grazing. The change to feeding on grasses and to life on the plains was accompanied by change of teeth. Greater speed was needed for safety and with this went the change from five-toed to one-toed hoofs. Elephants found safety along a different line in their tusks and great size. With the great number of herbivora, there came to be room also for smaller numbers of carnivora: a few lions feeding on many zebras; a few wolves feeding on many reindeer.

Forests and Primates

In temperate regions nut-bearing trees and squirrels depend upon each other. The squirrel's habit of burying nuts is often equivalent to planting them. The fruits of tropical forest trees grow mainly in the upper parts of the branches, and can be reached by few animals other than birds and the diversified tree-living mammals, the primates. In the Old World tropics the large fruit-eating bats, called flying foxes,



ORANG-UTAN EATING DURIAN FRUITS

doubtless have a part in seed distribution. But the primates are the principal fruit-eaters and seed distributors of tropical and subtropical regions.

We know from fossils that many mammals were much smaller in former periods, and this applies to primates also. Fossil primates are rare: a few monkeys and apes are from the late Cenozoic periods; lemurs also from the Eocene. Evolution within the order Primates is to some extent seen in fossils, but is also clearly suggested by the living groups; namely, lemurs, tarsius, marmosets, American monkeys, Old World monkeys, anthropoid apes, and man. Size seems to increase approximately with the accumulation of specialized characters. Tarsius, with enormous owl-like eyes, and marmosets are the smallest, man and gorilla the largest of the primates. Although primates are advanced in brain development, in several other characters they are primitive. As compared with carnivora, herbivora, or rodents, their teeth are primitive. Hands and feet with five digits is also a primitive character. Increasing adaptations to life in trees and increasing intelligence are specialized characters. Carnivora generally have multiple births, but among herbivora and primates a single young is the rule. That is about all the herbivora can defend, or that tree dwellers can manage at a time. Nearly all primates have only two milk glands.

Early mammals are known to have been small; they were probably insectivorous, tree-living marsupials. The opossum, only American marsupial, in many ways suggests primitive mammals. Lemurs resemble insectivora; several of them have marsupial characteristics.

Monkeys have smaller jaws and nasal cavities than lemurs. These characters of the higher primates have reduced the effectiveness of the sense of smell, but have improved vision. In lemurs the eyes are directed sideways as in most mammals and in lower animals, but in tarsius and in the higher primates they are directed forward. Thus attention may be given to the same object with both eyes; that is, they have stereoscopic vision with ability to judge distances—very necessary in tree life. Keen vision, a partly upright position, and increased use of hands have a definite relation to food habits, for monkeys see rather than smell what they are eating. They are far better able than other mammals to select deliberately the fruits which they prefer; that means usually the larger ones or the more fleshy ones. And they have been selecting them for a long time.

American monkeys are smaller than those of Asia and Africa; they are more strictly tree-living. Annonas, sapodilla, and Brazil nuts are eaten by American monkeys as well as by man; mango, banana, litchi, citrus fruits, and many others by Old World monkeys. Baboons and macaques have largely reverted to ground life, living in nearly treeless regions. They eat roots and tubers, the pith of aloes, insects, and ostrich eggs and they often devastate orchards.

The anthropoid apes are larger than monkeys and have no external tail. About ten species of gibbon live in southeastern Asia and adjacent islands. The orang-utan lives in Borneo and Sumatra. Wallace wrote that "their food consists almost exclusively of fruits, with occasional leaves, buds and young shoots. They waste and destroy more than they eat, so there is a continual rain of rejected portions below the tree where they are feeding. The durian is a special favorite. The orang is the strongest animal in the jungle." It is interesting that the

durian has approximately the same distribution as the orang-utan. In mid-Tertiary times the durian may have been a good deal smaller and less juicy, and so with other fruits. The gorilla and chimpanzee are African. The full grown gorilla is a ground dweller and eats large quantities of umbelliferous roots.

The primates nearly all live in tropical climates, though a few monkeys live in the Himalayas and northeastward where snow occasionally falls. The special characteristics of primates are connected with their life in trees, where they have a relatively secure food supply. Their greater safety as compared with animals on the ground has given them some degree of leisure. Hand and brain developed together and resulted in an intelligence in which the higher primates surpass all other animals.

Plants and Animals

"Classification instead of being simply a means of separating forms, has become a method of studying affinities, and tracing the phylogenies of groups of organisms," wrote L. M. Underwood nearly fifty years ago. Just what are the principal groups of plants and animals? The answer has been a changing one, as we gradually have learned about the course of evolution. The highest groups of organisms such as flowering plants and vertebrates differ from one another in obvious ways. But the lowest groups are not sharply separate; for example, flagellatae are on the border line between plants and animals. Life forms seem to be united at the base, like the letter V, except that the plant part is far larger in bulk than the animal part. Perhaps we may think of plants as two divergent lines. Thus we have: green plants, fungi, and animals. Fungi have neither chlorophyll nor mobility, while green plants have chlorophyll and animals have mobility. With the ability to move, animals have developed a nervous system and special sense organs, not needed by plants. Green plants use light to build up organic materials from inorganic ones; fungi and animals cannot do this. Plants are stationary or have at most limited mobility of certain parts; animals have the ability to move, at least during part of their lives. The higher plants need locomotion on two occasions in their lives; namely, in the transfer of pollen and in the distribution of seeds. Just what do we mean when we say plants are alive? Their interests are not ours, but they do have remarkably sensitive relations to moisture, to gravity, and to wind; and especially they have a sensitiveness to light far surpassing that of animals. Roots spread out in the soil to get water and its mineral solutions; leaves spread out in the air to get light and carbon dioxide.

Green plants need light for energy with which to make their own food; animals use the food which plants make. The forms of animal groups seem to a large extent to depend on their different ways of getting food. The earliest life forms may have been so simple as to be neither plants nor animals. They may have utilized inorganic compounds as sources of energy and as material for growth, as some bacteria do today. Or it is possible that the action of light may have been associated with the earliest organic life. Once light-using organisms had come, they built up energy-storing carbohydrates and at the same time set oxygen free. Then the stage was set for other life forms that could use these organic foods and the oxygen.

To some extent plants and animals have evolved in similar directions. For example, they have changed from small to large size, with some exceptions. At first plants and animals had soft bodies; later they acquired hard parts. Among the early organisms there was slight provision for the next generation, but among the higher groups this is increasingly important. The great step from water life to land life was taken by both plants and animals about Silurian times, and changes of form became necessary. Plants had to acquire roots and strong stems and leaves. Seeds came very early, apparently in the Devonian period; flowers and fruits ages later. Among animals the fins and airbladder of fishes were transformed to become the legs and lungs of amphibians. In time amphibians became reptiles, and two branches of reptiles became birds and mammals.

"There is another side to evolution so ob-

vious that it is often overlooked, the tendency to link lines together in vital interrelations,'' wrote J. Arthur Thomson. Animals may eat other animals, but the first link in the food chain is always green plants. Sea-living animals are ultimately dependent almost entirely on diatoms. On land, interdependence develops in connection with the increasing differences between plants and animals. Worms and plants with roots occupy the soil together and have long influenced each other. For ages pollen was transferred only by the wind. When insects became pollinators, the consequences in the development of flowering plants were far-reaching. The spread of flowering plants meant many more insects and more birds. More insects meant more of the small insectivorous mammals. Then came varied groups of larger and specialized mammals, with plant and animal interdependence along new lines, leading up to that between man and food-producing plants. Thus the dependence of the two great worlds of life on each other throws light on successive stages of organic evolution.

IRONY*

An arid daylight shines along the beach
Dried to a grey monotony of tone,
And stranded jelly-fish melt soft upon
The sun-baked pebbles, far beyond their reach
Sparkles a wet, reviving sea. Here bleach
The skeletons of fishes, every bone
Polished and stark, like traceries of stone,
The joints and knuckles hardened each to each.
And they are dead while waiting for the sea,
The moon-pursuing sea, to come again.
Their hearts are blown away on the hot breeze.
Only the shells and stones can wait to be
Washed bright. For living things, who suffer pain,
May not endure till time can bring them ease.

—AMY LOWELL

* From *Sword Blades and Poppy Seed.* Reprinted at the suggestion of Professor Arnold Dresden.

SCIENCE ON THE MARCH

THE NEW CYCLE OF SUNSPOTS

The early months of 1944 have seen the lowest record of sunspot numbers for over a decade, indicating that we are now passing the so-called minimum of solar activity. However, the new solar cycle is now under way; for before the period of actual minimum sunspot activity has occurred, the first spots of the new coming activity invariably appear.

The new spots are distinguished from the last spots of the old cycle in two ways: first, the former appear at high latitudes, usually 40° or more from the sun's equator; second, the magnetic fields of the new groups have a polarity opposite to that of similarly situated spots of the old cycle.

The first group of sunspots identified as belonging to the forthcoming cycle was observed on May 16, 1943. Its magnetic polarity was definitely determined by the Mt. Wilson observers as opposite from that of the old sunspot groups. The new sunspot group appeared on the southern hemisphere of the sun at a mean latitude exceeding 40° from the solar equator. While there is some uncertainty involved in predicting the exact time of the next sunspot maximum, one may confidently forecast increasing numbers of these solar disturbances in the next four or five years, to be followed by gradual decline.

The generally accepted average duration of a sunspot cycle is 11.3 years, but the actual interval between maxima or between minima may vary from nine to seventeen years. The interval between maxima of the last few cycles has been definitely less than the average interval. The last maximum, occurring in the middle of the year 1937, followed the previous maximum of 1928 by only nine years.

Interest in the solar cycle has been much more acute of late because of the importance of the relation between the occurrences of sunspots and radio reception. The ionization of the upper atmosphere, frequently referred to as the "radio ceiling," definitely increases with the advance of the sunspot cycle. The ability to forecast wavelengths and frequencies for best radio communication between various parts of the world rests in no small measure upon the ability to anticipate the occurrence of the disturbances on the sun that have been known for 300 years as sunspots.—HARLAN T. STETSON.

PHOTOPERIODISM IN PLANTS

THE cyclical alternation between night and day is one of the most obvious of natural phenomena. Under natural conditions long periods of daylight automatically correspond to short nights, and vice versa. Over most of the surface of the earth marked variations occur from season to season in the length of the daily photoperiod (number of hours of illumination). Despite the self-evidence of seasonal variations in day-length, it was not until 1920 that experimental evidence was forthcoming which demonstrated that the duration of the daily photoperiod was an environmental factor of paramount importance in influencing the developmental behavior of plants. Although this factor also has recognizable effects upon the vegetative growth of plants (the development of leaves, stems, and roots), its most significant influences are upon the development of flowers and other phases of reproductive growth.

As a result of the earlier investigations of photoperiodism, plants were found to fall into three more or less well-defined categories: (1) "long-day" species, which flower more or less readily in a range of photoperiods longer than a certain critical period, developing only vegetatively in all shorter photoperiods; (2) "short-day" species, which flower more or less readily in a range of photoperiods shorter than a certain critical period, developing only vegetatively at all longer photoperiods; and (3) "indeterminate species," which exhibit no critical photoperiod, developing both vegetatively and reproductively over a wide range of photoperiods. In both the short-day and long-day species the length of the critical photoperiod differs according to species, but it often lies within the range of 12 to 14 hours.

Some common examples of short-day species are asters, dahlias, chrysanthemums, salvia, and cocklebur; of long-day species,

spinach, radish, lettuce, beets, and grains; of indeterminate species, sunflower, tomato, cotton, and buckwheat. Both short-day and long-day varieties may exist even within the same species. Most varieties of soybeans, for example, are long-day plants, but a few varities, including the well-known Biloxi, are of the short-day type.

In temperate regions the season of blooming of a plant is largely determined by its photoperiodic reactions. Short-day plants, in general, bloom in the early spring or early fall; long-day plants in the late spring or summer. The geographical distribution of many kinds of plants is also in part a function of their characteristic photoperiodic reactions. Obviously a species cannot maintain itself in a climatic zone in which it is impossible for the cycle of its reproductive processes to be completed. In addition to improving our comprehension of the behavior of plants in nature, an understanding of photoperiodism has been used to advantage in controlling the time of blooming of certain plants. Practical use of the knowledge of photoperiodism has found its most widespread application in the greenhouse culture of floricultural crops.

Recent investigations by Russian and American plant physiologists, particularly the latter, have considerably advanced our understanding of the mechanism of photoperiodism. One of the most important discoveries is that the leaves are the loci of the reactions leading to the initiation of flower development. If the leaves of short-day cocklebur or Biloxi soybean plants are exposed to long photoperiods, while the differentiating tissues (meristems) at which axial growth occurs are exposed to short photoperiods, development of flowers does not take place. If, however, the leaves are exposed to short photoperiods while the meristems are exposed to long ones, differentiation of flowers soon begins. Similarly, if only the leaves of long-day dill plants are exposed to photoperiods of suitable length, development of flowers starts very shortly.

The results of certain types of grafting experiments also point to the same conclusion regarding the role of the leaves in the photoperiodic reaction. If a short-day variety of soybean is grown under photoperiods of 17 hours, flowers never develop. If, however, a leaf from a long-day variety is grafted on the short-day plant, formation of flowers soon starts even if exposure of the plant to 17-hour photoperiods is continued.

These experimental results indicate not only that the leaves are the loci of the reactions which induce the blossoming of plants, but also that the influence of processes which occur in the leaves is transmitted to the meristems, causing them to differentiate into floral organs. It appears to be a valid inference, therefore, that a hormone-like substance or substances, synthesized in the leaves only under suitable photoperiodic conditions, is translocated to the meristems, inducing differentiation of floral parts. The name "florigen" has been proposed for this hypothetical flower-inducing hormone. There is evidence that this substance (substances?) can be translocated both in an upward and downward direction in plants, but the distance it can move from the leaves in which it is made seems to differ according to the kind of plant.

If a vegetative short-day plant is transferred from a long day to a short day and exposed to several short-day cycles and then returned to a long day, flowers develop even under long-day conditions. This phenomenon is called "photoperiodic induction." The same phenomenon occurs in long-day species if vegetative plants growing under short-day conditions are transferred to a long day, exposed to a suitable number of long-day cycles, and then returned to short days. The number of suitable cycles required for photoperiodic induction varies according to species.

A fundamental physiological difference between short-day plants and long-day or indeterminate plants is that the former require a cyclic alternation of light and dark periods if flowers are to develop, whereas the latter do not. In other words, short-day plants might just as appropriately be called "long-night" plants. Flowering in the short-day Biloxi soybean, for example, is induced only if the plants are exposed to a suitable number of dark periods, each more than 10 hours long, alternating with light periods of not less than about 2, nor more than 20, hours and optimally about 11 hours in length.

A reasonable inference from the photoperiodic requirements of short-day plants is that a certain reaction or chain of reactions occurs in the leaves during the dark period and another reaction or chain of reactions during the light period, both of which are essential to floral initiation in such species. Other evidence suggests a further interaction between the products of the light and dark syntheses, the final product perhaps being the postulated "florigen."

The intensity of the light as well as the duration of the period of illumination is also a factor which influences the light reactions necessary for flower development. In the Biloxi soybean, for example, many more flower rudiments (primordia) develop under an illumination of 400 foot-candles than under an illumination of 100 foot-candles.

The dark reactions leading to floral initiation are extremely photosensitive and must proceed without interruption for a period of minimum duration if they are to be effective. For example, in the cocklebur a dark period of sufficient length to be effective in inducing floral initiation becomes completely ineffective if interrupted at its midpoint by as little as one minute of light of even relatively low intensity.

Long-day plants, in contrast with short-day plants, do not require an alternating cycle of light and dark periods. This is shown by the fact that such plants blossom even when exposed to continuous illumination of suitable intensity. However, long-day plants do require a light period of minimum duration out of each 24-hour day in order for floral initiation to occur. For example, in dill, a representative long-day species, the minimum length of the photoperiods required for flower development is between 11 and 14 hours.

The mechanism of the photoperiodic reactions leading to blossoming in indeterminate species appears to be more nearly like that of long-day species than of short-day species. In general, however, indeterminate species can bloom under shorter daily photoperiods than long-day species.

In evaluating the photoperiodic reactions of plants the modifying effect of temperature must also be considered. Apparently temperature exerts a profound effect on at least some of the reactions which control photoperiodic behavior. In general the temperature of the dark period appears to be more critical than the temperature of the light period. Examples are known of species which exhibit the characteristic reactions of short-day plants at one night temperature and the characteristic reactions of long-day plants at a different temperature.—B. S. Meyer.

CAMOUFLAGE PAINT SPRAY

Before the earth-rocking thunders of Pearl Harbor had died away, the entire scientific fraternity of America had become alert to the great demands that would be levied upon its every member. There was so much to know and so little time in which to learn! Every research organization was anxious to convert its equipment and resources to best adaptation for the war effort.

Most of the tree-expert companies in the country turned their attention to camouflage work, which became more and more important as aerial warfare rose to meteoric ascendancy. For many, although not all, types of camouflage involving ground assemblages, it was perfectly obvious that there was no satisfactory substitute for the living tree, shrub, or plant. Large scale plantings and seedings were undertaken to effect a blending of military objects with their surroundings. Grouping of shrubs was practiced to simulate outlines of larger trees, in some cases to give the desired effect quickly. To produce an array of blending colors which would be confusing to the aerial enemy, however, it became necessary to employ paint and pigments on a hitherto unheard-of scale. The application of paint is intended to camouflage objects or areas where trees or shrubs cannot be planted, such as landing strips, roads, and certain types of buildings.

What speedier or more effective method of applying such paints than in the form of a spray, by means of large, high-power spraying machines such as are used to spray shade and forest trees for the control of insects and fungus diseases? This possibility was put to the test just as soon as paint-spraying materials could be obtained. After a few trials, however, it became obvious that the heavier and more costly paints could not be used

in these spraying machines because they clogged the finer parts of the apparatus. On the other hand, the lighter cold-water paints, which were amenable to application by power sprayers, proved unsatisfactory for other reasons, chief of which was the failure of the paint film to build up on the sprayed surface and to resist weathering after it had dried.

It seemed very desirable to develop a paint spray the ingredients of which could be mixed in the tank of the sprayer itself. Such manufacture of paint in the field would obviate mixing, grinding, and packaging of the pigment and vehicle in the factory, thus saving both time and money. To approach this primary objective required the development of an entirely new spray paint combination that could be applied by means of a power sprayer and at the same time would meet specifications for pigment coverage, color, and durability.

The Bartlett Tree Research Laboratories was in a particularly good position to conduct investigations on this problem because one of the company's major research projects had long been the testing of stickers and spreaders for insecticidal sprays. A great deal of time was thus saved by quickly eliminating materials already known through years of testing to be susceptible to the influence of weathering.

After a great number of different types of vehicles and pigments had been tested, it became apparent that best results were being given by those vehicles that would yield a vehicle-pigment combination completely emulsifiable in water. It was further necessary to restrict vehicles to those that would be sufficiently thin for spraying, would cover a surface quickly, and would dry rapidly thereafter.

Experiments finally limited the field to two resin vehicles, one an alkyd resin and one an oleoresin. The latter was adopted because it was easier to handle and dried more quickly after application. The performance of this oleoresin—a linseed oil emulsion—left little to be desired in large-scale application to a great variety of surfaces. The combination was given the name *Bartlett Spracote*. Applications of *Spracote* on macadam roads under conditions of light traffic were still in a satisfactory condition over a year later, while on concrete highways this cold-water-pigment-vehicle combination stood up well for several months under heavy traffic.

One particularly interesting application was made to a planting of thirty-six hundred evergreen trees where branches and needles had died and had become brown, producing a conspicuous contrast with the live green needles. Green-colored *Spracote* applied here caused the needles to look like live green foliage—an effective impression which has persisted now for nearly a year.

Another outstanding development of the Camouflage Spray Research program was the incidental discovery of a synthetic resin that does not injure living plant foliage. There are great possibilities in the adaptation of this material to postwar agricultural spraying for pest control, for it possesses unusual adherent qualities and may also have some insecticidal value.—S. W. Bromley, Bartlett Tree Research Laboratories.

BOOK REVIEWS

GARDEN ISLANDS OF THE GREAT EAST

Garden Islands of the Great East. David Fairchild. Illustrated. xiv + 239 pp. $3.75. 1943. Charles Scribner's Sons.

In these days of grim and relentless offensive against the stolen "Empire" of Japan, such names as the Philippines, Celebes, Java, and the Moluccas principally suggest military objectives. Dr. Fairchild's *Garden Islands of the Great East* is, therefore, particularly refreshing to the spirit because of the pictures it paints of these charming lands at peace and of their interesting plants and people. We journey with Dr. and Mrs. Fairchild and party as guests of Mrs. Anne Archbold on the motorized junk "Chêng Ho" from the Philippines to Celebes, Java, and a portion of the Moluccas. The latter are a group of small and poorly-explored islands lying between Celebes on the west and New Guinea on the east. For forty years it had been Dr. Fairchild's dream to explore botanically the Moluccas or "Spice Islands." On this expedition, the dream was fulfilled to the extent of brief visits to a few of these islands including Boeroe, Manipa, Amboina, Mandioli, and Halamahera. Soon after the "Chêng Ho" had come to anchor in the harbor of Amboina, the invasion of Holland by the Nazis was announced and the plans for a liesurely cruise among the Moluccas had to be abandoned. Despite this bitter disappointment, it was possible to return to the Philippines via the coast of Halamahera. This permitted the collection of seeds of a number of interesting Moluccan plants as well as a general survey of the coastal vegetation.

As Dr. Fairchild emphasizes, the expedition's scientific results are not to be measured by bundles of dried plants destined for herbaria and technical classification by specialists. On the contrary, he returned "to hundreds of thousands of little seedlings which were already growing up and getting ready to make their debut as Plant Immigrants on the stage of American Horticulture." Among these newcomers are more than ninety varieties of palms, and all students and admirers of this amazing group of plants will hope for their successful development in the Fairchild Tropical Gardens in Florida. The emphasis on the collection of living plant materials, such as seeds, cuttings, and tubers, required special techniques which are described in an interesting way throughout the narrative. Needless to say the availability of air-transportation greatly decreased the loss of all specimens, many of which reached Miami nine to ten days after collection.

In the reviewer's opinion, one of the most significant accounts in the book is the brief and understandably sad description of the famous Botanical Garden at Buitenzorg, Java. This garden is intimately associated with the name of Treub and it was in the company of this illustrious Dutch botanist that Dr. Fairchild in 1894 had his first glimpse of "the world of palms." Now, forty-six years later, the charm and the challenge were still there. One can only wonder whether the Buitenzorg Garden will still exist to educate and inspire other young botanists when the world is once again at peace.

Like Dr. Fairchild's previous books, this volume is sufficiently nontechnical to appeal to a wide audience. The layman will particularly enjoy the numerous excellent and instructive photographs as well as the pleasing style of the author, which is often enlivened by humorous or philosophic comment. To the botanist, the book is an invitation to retrace, at some happier period in the future, the author's journey and to see for himself some of the extraordinary plants which are so vividly described.—Adriance S. Foster.

AMERICA'S GREATEST INVENTORS

America's Greatest Inventors. John C. Patterson. xi + 240 pp. 1943. $2.00. Thomas Y. Crowell Co.

The inventor presents to the mind a bundle of paradoxes. Frequently almost completely ignorant of all but the superficial bases of the science in which he makes his inventions, he nevertheless seems to possess the capability of dissecting from any greater depth of fundamental knowledge as much as

he happens to need for the moment to further his schemes. To the academic mind he is a mystery. At one time he lives in the clouds, which are supposed to be the natural home of all absent-minded professors. At another he becomes the most practical of business men, dabbling in the world of finance in all sorts of conventional and unconventional ways. Perhaps the greatest mystery which he presents to the scholar in this connection lies in the fact that he can find an interest in these matters of promotion, seemingly so foreign to the mind of the student of pure science. Even the urge of reward is not enough to afford an explanation; for, unless that urge is but an accompaniment to a deeper urge inherent fundamentally in the interest born of the task itself, it is doubtful whether any success such as characterizes the greater men of the world would ever be attained.

Not the least of the astonishing situations which characterize most inventors is a keen sensitivity to all matters concerned with patents. To the academic mind, patents are frequently things of another world. They cost no inconsiderable amount to secure, and the academic researcher does not quite know what to do about the matter when the patent is obtained. However, we find the inventor at the earliest age, without any money or resources, somehow or other getting patents on everything he handles. How he does it borders on the miraculous.

For all of the foregoing reasons, it is of particular interest to have this book by John C. Patterson, which collects the pictures of seventeen of America's most noted inventors and places them before us in one setting. We are able to form some judgment of the extent to which they have in common characteristics which may be said to be peculiar to the inventor's psychology. We are able to compare the circumstances which have promoted or retarded their success, and the author has adopted a uniform pattern of exposition which makes such comparison particularly easy. The reader can hardly expect to fathom completely the psychology of the inventor's mind by reading this book, but at least he will gain a composite picture of that individual whose peculiarities invite explanation. The book constitutes very interesting and easy reading. There is no undue elaboration of detail and just enough scientific exposition to make clear the purposes of the inventions to which reference is made.

The persons whose lives are summarized are Eli Whitney, Robert Fulton, Cyrus H. McCormick, Samuel F. B. Morse, Charles Goodyear, Elias Howe, Jr., C. L. Sholes, George Westinghouse, Jr., Alexander Graham Bell, Thomas A. Edison, Nikola Tesla, Charles N. Hall, Ottmar Mergenthaler, Orville and Wilbur Wright, Lee De Forest, Leo H. Baekeland, William M. Burton. Naturally the list of what may be called prominent inventors is not complete, and some may question the selection which has been made to the exclusion of other names which have been associated with great inventive genius. Moreover, the allotment of credit for certain inventions is occasionally a controversial matter. Thus, for example, Edison is claimed as the inventor of the moving picture, whereas, if this reviewer recalls correctly, there has been considerable difference of opinion on this matter, and the claims of others have been strongly urged. However, these are matters of detail, and the author may be congratulated on producing a book which will be read by the man of science and by the layman with equal interest.—W. F. G. SWANN.

THE DELECTABLE MOUNTAINS

The Great Smokies and the Blue Ridge. Edited by Roderick Peattie. Illustrated. x + 372 pp. 1943. $3.75. The Vanguard Press.

WHEN old John Bunyan in his *Pilgrims Progress* described the Delectable Mountains as the next thing to heaven, he could not have foreseen that they would ever become a national park, and surely if he could now observe the throngs of pilgrims who stream into the Great Smokies, he would wonder how some of them managed to get that far on the road to bliss. In the opinion of the reviewer, who has a fair acquaintance with American mountains, the region in and about the Great Smokies National Park is the loveliest of all. The highest mountains east of the Black Hills, their ruggedness is cloaked with forest-cover to their very tops. Since they have never been submerged nor touched by glaciation, they have been a center of distribution

of plants and animals since terrestrial life first began. Within the limited area of the Park there are 130 species of trees (50 per cent more than in all Europe) and 1400 kinds of flowering plants, and the animal life is equally rich and varied. Thus the region is even more interesting to the naturalist and nature lover than it is to the mere sight-seer.

It is therefore particularly satisfying to have this authoritative work on the Great Smokies and the adjacent Blue Ridge. It is the work of seven excellent writers, each a specialist in his own field who has spent many years in his study of this area. The editor is Dr. Roderick Peattie of The Ohio State University, a well-known geographer and author who has been familiar with the region since childhood.

Three chapters, "Indian Days and the Coming of the White Man," "Men, Mountains and Trees," and "Blue Ridge Wild Flowers," are contributed by Donald Culross Peattie, an able scientist and one of our most brilliant writers in the field of natural history. Three chapters, by different authors, are devoted to the human side of the picture. Alberta Pierson Hannum deals very clearly and sympathetically with "The Mountain People" and their nature, way of life, beliefs, and humor. With full knowledge of their subjects, Ralph Erskine writes of "The Mountain Craftsman" and John Jacob Niles discusses "Folk Ballad and Carol" all too briefly, for each of these subjects deserves a volume.

The geologic story, a very complex record of a billion years or so from Pre-Cambrian time to the present, is simplified for the reader by Dr. Henry S. Sharp, who also explains the fascinating peculiarities of the drainage systems. Ralph Erskine gives a good answer to the question "What About the Climate?", noting and explaining the local vagaries and sums it up with the statement that "it is not like anything else in the country."

The Park Naturalist, Arthur Stupka, in his chapter "Through the Year" presents an illuminating description of the Great Smokies, month by month as the seasons change, based on voluminous notes made during his years as resident naturalist. In the final chapter Edward S. Drake, a native of the region who returns as often as he can make an excuse, presents valuable information on the planning of trips. His maps show the roads and main trails, with distances to be covered, and he notes the chief scenic features of each route.

The book is beautifully illustrated with characteristic scenes and contains a good bibliography and an index. It is a very informative and satisfactory account of one of the most interesting and charming sections of our country. The armchair tourist will find much enjoyment, and those who have visited the region will appreciate it as a record of their experience.—R. C. OSBURN.

AMERICAN BIRDS

The Illustrated Encyclopedia of American Birds. Leon Augustus Hausman. xix + 541 pp., 700 illus. 1944. $1.98. Halcyon House.

THE author of this book is professor of zoology in the New Jersey College for Women, Consulting Ornithologist of the New Jersey State Agricultural Experiment Station, and lecturer in ornithology at Rutgers University. The book is based on some thirty years' experience in field work and in teaching biology and ornithology. In addition to an introduction and a discussion of "how to use the book" (pp. i–xviii), the main part of the volume comprises an alphabetical arrangement of bird subjects under various headings by family, species, and subspecies (pp. 1–468). This is followed by a systematic or classified list of North American birds (pp. 469–503) based upon and reproduced from the well-known A. O. U. *Check List of North American Birds.* Also included is an index of other names of North American birds, (pp. 505–533), an index of scientific names of families (pp. 534–535), a list of Official State Birds of the United States (pp. 536–537), and a bibliography of books useful to laymen in the study of birds (pp. 538–541), including 88 titles of standard books on the subject. The respective entries in the alphabetical sequence include common and scientific names and a brief discussion each of adult male and female; length, distribution, and other like data. Much of the subject matter is supplemented by appropriate drawings. Especial effort has been made to include descriptions of

every bird ever reported from the North American continent, a total of 1422 species and subspecies. Each of the 75 families is described, with data on birds' songs, nests, eggs, and general habits. The Encyclopedia omits discussion of all fossil birds except *Archaeopteryx*, or Lizard Tailed bird, which, being at the present time the oldest known bird, is a matter of interest to all devotees of ornithology. The needs of the nontechnical student have been particularly stressed in the preparation of this work, and this feature alone should add greatly to its usefulness. Then too, those responsible for its publication during these days of wartime stress on economy and conservation of resources are to be commended for the more than reasonable price they have set upon this first edition. It is so low as to place the book within the price range of popular reprints, which should greatly widen and augment its distribution.—J. S. WADE.

TOMORROW WE FLY

Tomorrow We Fly. William B. Stout and Franklin M. Reck. Illustrated. 160 pp. 1943. $2.00. Thomas Y. Crowell.

A BOOK for the layman, or for the scientist who is not a technologist, this little volume gives, readably yet from the expert viewpoint of the designer of the first all-metal (Ford) plane, the tale of the past projected into "the shape of things to come in aviation."

Tomorrow is, of course, the lodestone of science. It is stimulating, therefore, to hear from technologists that we are not yet actually flying. The "wings" we are using are crude—hardly wings at all because they lack flexibility. They cannot "spill" the gusts or rough spots in the air, for example, as a sail on a boat does, and have accordingly to be built to stand terrific strains; all of which makes air-riding rougher than it need be or than it is in the natural flight of birds or insects.

The authors predict, for these reasons, a future for a form of flight which we might call *entomo*pterous rather than *ornith*opterous because "birds have individual feather actions that may be hard to duplicate," while "an insect wing . . . is structurally much more simple" and "easier to study." The outlook is even narrowed down to *odono*pterous flight; that is, to the easy way of the dragonfly in outdoing the helicopter in instant control of direction.

If we do take our patterns from nature, however, this reviewer would point out that the hummingbird is almost as expert in control as the dragonfly. The familiar flight of the little ruby-throat is strikingly like that of the hawk moths. Is this because this birdlet falls closest to the range of insects in size? The flight of the largest birds that have retained expertness in the air is characterized by large wings which move slowly. Moreover wings seem to have been disposed by nature bilaterally without exception, as is the case with all locomotor appendages. Such rotary motion as wings have in birds seems to be damped by their eccentric attachment and longitudinal arrangement so that they "flap" the air to the rear after picking up and compressing a charge by the rotation of the front edge of the wing. Is this possibly a commingling of jet and propeller action? The authors hint broadly of fast British planes with auxiliary jet propulsion. They doubtless knew of the propellerless planes now revealed, but obviously felt that wings, affording some recourse if power fails, could not be discarded and would provide the ultimate in maneuverability.

That the limit of usefulness in speed may be reached before the limit in potential performance is suggested, now that "going like sixty" refers, not to miles per hour, but to hours per trip around the "world" of the upper latitudes. On the other hand, lowered costs may present startling developments. What a saving of rubber as air touring takes the place of the auto traffic of today! Some of our plane capacity will carry freight, perhaps at 20¢ per ton-mile (prewar dollars!). Here light weights (new metals, dehydration, etc.) and development of resources (tin, rubber, etc.) by air transport may bring such continental self-sufficiency as to imply less rather than more worldwide trade, despite the ton-mile cheapness of water transport.

"Blind as a bat" has had reference to inability to see with light. But men in aircraft are imitating the bat in using other means of avoiding unwanted contacts in the air.

Supersonic sounds are the bat's way; short-wave electronics are our way of detecting objects that cannot be seen. The shape of things to come in this subatomic field seems nebulous, though atomic fission suggests to these authors a new source of power no longer tied to the solar radiation upon which organic existence has been entirely dependent throughout geologic time. For the present, lest tomorrow we *die*, the human economy will have to confine itself to the conservation of *solar* energy and a correlatively limited population, even in a "new world order."—ALDEN A. POTTER.

CANADIAN-AMERICAN MIGRATIONS

The American-Born in Canada. R. H. Coats and M. C. Maclean. xviii + 176 pp. 1943. $3.75. Yale University Press—Ryerson; *The Canadian-Born in the United States.* Leon E. Truesdell. xvii + 263 pp. 1943. $3.00. The Ryerson Press—Yale.

THESE two volumes belong to a series of studies on the relations of Canada to the United States, sponsored by the Carnegie Endowment for International Peace. The first of this series was Marcus Hansen's *The Mingling of the Canadian and American Peoples* (1940), an historian's account of the changing currents of migration across the Canadian-American border accompanying the westward advance of settlement and varying economic conditions. The two present volumes are in part the statistical sequels of the earlier work, presenting the net effects of this interchange of population as reflected in the Canadian censuses of 1851 to 1931 and in the United States censuses of 1850 to 1930 inclusive. The general reader will probably find the historical account more entertaining, but for the student of migration or of Canadian-American relations, the studies of census materials are invaluable as sources of data and as analyses of the intermixture of the two peoples.

It is known in a general way that the Canadian-American border has been of little hindrance to migration, and that the two countries have interchanged population freely. The net results of this interchange are revealed by the census data. In Canada it is found that the American-born are widely diffused throughout the country and are quite evenly distributed in all major occupations and industries. The Canadians in the United States, especially those of French stock, have shown a greater tendency to concentrate, being most numerous in the cities of the northern and northeastern states, and being employed predominantly in industry. In terms of the numbers involved, the migration has been a much more serious drain on Canada, it being estimated that as of 1931 one out of every eight native Canadians was residing in the United States. On the other hand, the United States apparently has lost less than one-third of one percent of its people to Canada.

The census data of both countries permit a detailed study of the migrants according to geographical distribution, sex, age, marital status, occupation, date of entry, and citizenship. The Canadian material contains additional information on intermarriage and on the religion of the immigrants. The United States census appears somewhat more detailed with regard to family size and economic status, but on the whole, quite comparable accounts are given of both migration groups.

Both analyses are careful and detailed. There is only one point on which no information is given, and that is on the degree of reliability of the data. One might suspect that with such an intimate mingling over so long a period of years, the origin of some of the migrants could easily be overlooked. There is probably no answer to this question of reliability, but any indications would be helpful to the reader.—E. P. HUTCHINSON.

SALAMANDERS OF NORTH AMERICA

Handbook of Salamanders. Sherman C. Bishop. 569 pp. 1943. $5.00. Comstock Publishing Company.

THE salamanders as an order of the Amphibia comprise a group of animals of interest to an increasingly larger number of students. Seldom seen by the layman, salamanders are sought by the naturalist with a sense of "fisherman's luck" that spurs him on. Their very elusiveness, the variety of their form and color, the specific differences in their life histories and behavior, and the sharpness with which their distribution in an area is delineated by ecological niches, lends zest to the study of salamanders by the field zoologist.

Dr. Bishop's recently published *Handbook of Salamanders* is not simply an annotated taxonomic listing of species in this group; it is a highly readable, thorough-going summation of our knowledge of the biology, taxonomy, and occurrence of salamanders in North America, written by a recognized authority who brings together the results of wide field experience and a scholarly digest of the literature.

The salamanders of the United States, Canada, and Lower California are herein described as numbering 126 species and subspecies. This includes all but two of the 102 species recognized in the fourth edition of Stejneger and Barbour's *Checklist of North American Amphibians and Reptiles,* 1939. The twenty-six more recent additions considered valid by the author complete, up to the date of publication, the list of recognized species and subspecies of salamanders of this area.

An over-all concept of salamanders as an order of Amphibia is presented in the introductory chapter in which the author briefly discusses relationships, courtship patterns, care of eggs, neoteny and habitat niches, methods of collecting and preserving specimens, and the use of keys and maps.

The main body of the *Handbook* is concerned with accounts of species, dealt with individually but arranged by families and genera. Descriptions of each natural group of species are preceded by appropriate keys.

Species descriptions list the common name, scientific name, type locality range, and habitat. This is followed in each case by an account of the variations in size that may be encountered in a series of specimens as related both to sex and range of the species in question. Comments on color, markings, breeding time, and behavior have obviously been taken from field notes.

Every species described is illustrated. Adults have been photographed from live specimens, except when indicated, and often from dorsal, lateral, and ventral aspects. Photographs of egg masses and larvae have been included when available.

Distribution maps, made with care and accuracy, and printed sufficiently large to show considerable detail, are an especially valuable contribution of this *Handbook.* Every species is represented in this array of 56 maps. Where subspecies are recognized, their comparative distribution is shown on a single map. Beyond these the author adds no comments as to distribution in relation to ecological factors, although these maps time and again stimulate so many questions in the reader's mind that he wishes Dr. Bishop had introduced some discussion in partial answer. Certain species of salamanders are shown to occur as far northward as the latitude of Hudson Bay and continuously southward to the Rio Grande, while others are confined to areas represented simply by a cluster of dots on the map. The instances of occurrence of salamanders in Alberta, southern Alaska, or northeastern Quebec pose intriguing questions, matched in interest by those pertaining to species whose distribution is remarkably local or discontinuous.

An index of authenticity of the text is the documentation throughout, based on a classified bibliography of 66 pages. Titles grouped as general works, checklists, life histories, and publications by states and provinces of the United States and Canada should prove helpful to the explorer of herpetological literature.

Bishop's *Handbook* is a welcome contribution and an indispensable volume in the library of every serious-minded herpetologist. —JOHN W. PRICE.

COMMENTS AND CRITICISMS

Teleology Reconsidered

In the May, 1944, issue of THE SCIENTIFIC MONTHLY, Professor Bahm has presented an excellent survey of the teleological argument. The question of purposivity always intrigues the human mind. The argument that "the world has a pattern and therefore must have a purpose" is one which, by reason of its satisfying assurance, makes a general appeal. This immediately raises a question. Why does the human mind seek evidence of a pattern and of a consequent purpose underlying ultimate reality? The answer is to be found in the basic emotional urge which is essential to the human psyche. Man's world is anthropocentric. Man wants to think of himself as the center of the universe. This attempt to explain the world to himself has proven both advantageous and disadvantageous. Negatively, this emotional drive has stood in the way of scientific progress. It explains, for example, the historic objection to the rejection of geocentricity in astronomy. It has served to man's advantage by bringing the realization to his consciousness that the world came into being because of himself. Consequently he utilizes every argument to establish ultimate purposivity. It cannot be denied that the persistent ascription of purpose to the universe gives added meaning to life and impulse to social progress. It is the hope which supplies the goal.

The foregoing argument presumes the acceptance of emotion as a legitimate constituent of human thought. Emotion, if properly directed towards desirable goals, can make a positive contribution to the line of human development. If we presuppose the validity of emotion in the realm of reason, we can find legitimate place for the teleological argument. Accepting this as a point of departure let us probe further into reasons favoring the teleological argument.

With the appearance of the scientific spirit, man begins the observation of nature. He realizes that the discrete manifestations cannot constitute the all of reality. He seeks for an ultimate explanation of the shadowy world of appearance. Gradually the multiverse of appearances give way to a concept of universe. These speculations do not constitute an end in themselves. A question immediately arises. What meaning has the universe—the universe of reality as opposed to the multiverse of appearance—to man? That is, what is the purpose behind the concept of pattern? The only possible answer must be in terms of ethics. Metaphysical speculation must lead to the discovery of ethical sanctions.

Thus we see that ethical conclusions follow as the result of every type of metaphysical inquiry. A non-metaphysical system of inquiry finds the explanation for ethics in mores and folkways. Metaphysical speculation ends in a search after ethical sanctions. For if ultimate reality is purposive and not illusory then ethical sanctions must prove effectually binding. If ultimate purposivity may be read into the universe, ethically binding sanctions must follow as a matter of course.

In this connection it is perhaps possible to cast the teleological argument into another form. Man's pre-eminent capacity lies in the power of perception. Man can think. Man's thought processes are apparently capable of infinite development. Can it not be legitimately argued that the possession of thought on the part of man must be explained as the extension of that thought which is the ultimate reality of the universe? To put it somewhat differently, since thinking man because of his apperceptive-perceptive capacity conceives the presence of purposive designs ranging from immediate experience to the interrelation of the self with the universe, it should follow that the reality beyond all appearance is purposive.

If the ethical sanctions which must follow find acceptance, the human mind will achieve increasingly higher moments in evolutionary development because proper direction will have thus been given to the fundamental emotional urge.—SOLOMON FRANK.

Pleasures and Purposes in Research

In Dr. Alan Gregg's Critique of Medical Research, published in the May, 1944, issue of THE SCIENTIFIC MONTHLY, the devotee of any branch of science may find one of the most encouraging statements of research strategy which has appeared in recent years. By a simple substitution of specific terms its principles became equally applicable in all fields of study, and the manner in which particular purposes are related to general needs sets a good example for all to follow. It was therefore particularly unfortunate, at least in the eyes of this reader, that such an admirable exposition should be marred by a minor statement reminiscent of the claims to royal prerogatives heard in a darker age than ours.

Dr. Gregg speaks very scornfully of those to whom the purely personal enjoyment of research does not provide an axiomatic justification of the demands they must make upon society, or even upon their own abilities, in the pursuit of their desire. As a contrast Dr. Gregg extols the virtue of accepting as sufficient in itself the "almost sensuous pleasure" experienced in the discovery of order and natural law, rejecting, as adulterants needed only by the timid, any corollary feeling of faith and conviction in the ultimate usefulness of all search for truth.

It might be well to remember that even the

Hawaiian missionaries of whom Dr. Gregg is reminded went out to do good to *others* according to their own lights and not merely to obtain the satisfaction of an "almost sensuous pleasure" for themselves only.

This sensuous pleasure in discovery is probably better known and more strongly felt in the subjects of so called "natural history" than in any other discipline, because it is the rule rather than the exception that the student of these subjects is first attracted to them by the sensory enjoyment of nature, rather than by an intellectually developed appreciation of its research problems. But to demand the right to do research at the expense of society in pursuit of a personal pleasure, without even feeling the need for any conviction about its ultimate usefulness, is to claim the privileges of an elite which is not accountable for itself in the manner of ordinary human beings.

To the writer it seems evident that the possession of knowledge is always useful even when the knowledge itself can not be put to practical use. And this conviction seems more than a mere belief developed as a rationalization of a desire. It seems a thesis which could easily be proved if an adequately equipped foundation should care to make a survey of the negative as well as the more conspicuous positive uses of knowledge in human progress.—A. E. PARR.

Adopted

Those of us who use THE SCIENTIFIC MONTHLY as reference material in our classes and who make up bibliographies from time to time would like it if you put a footnote at the bottom of the first page of the second section of a continued article, telling the reader where the first part appeared.—CHARLES J. PIEPER.

To Dr. A. J. Carlson

In your article on "The Older Worker" [THE SCIENTIFIC MONTHLY, July, 1943] you have tackled a problem that goes right to the heart of our civilization. You have marshalled considerable scientific data on the subject. It seems to me that scientific facts ought to go a long way to changing the attitude of the public on this problem. For the sake of the older worker and his contribution to society there should be further scientific study to support your contention. A study of a number of cases of forced retirement might make a contribution in support of a change of policy.

Educational institutions should take the lead in this matter but they evidently have not done as well as industry as shown in the examples of the "Old Man's Division" of the Dodge plant and in the case of the Ford industry. It would seem that in educational institutions where the work is primarily mental rather than physical there should be much concern to conserve the experience and wisdom of the older worker. A blanket provision of retiring all men at the same age completely disregards what is known about individual differences. The blanket retiring age is so unscientific and inhuman that educational institutions should not be a party to such practice.

It seems to me that there can be no valid objection to your proposal of reduced pay for reduced capacity and performance. From the standpoint of justice and decent human consideration for the individual and the welfare of society, our civilization cannot afford to continue to treat the older worker as though he were a commodity without flesh and blood. I know that a blanket retiring age makes it easy for administrators to deal with the older worker. But administration should be regarded as a means to an end and not an end in itself. Personnel departments of educational institutions and of industry and business should be able to work out techniques of dealing with the older workers that would remove the stigma of injustice that now rests upon these institutions.—C. H. FISHER.

Decimation

In "Comments and Criticisms" in the June issue of THE SCIENTIFIC MONTHLY, Peter A. Carmichael is in error when he says, "If Jevons took two seconds per throw . . . then he was at it for the equivalent of some fourteen eight-hour days; . . ."

If 20,480 throws required 2 seconds each, the experiment would have taken somewhat less than 11.38 hours—I presume Mr. Carmichael made a mistake in his decimal point and called this 113.8 hours.

Incidentally, I should like to know what Mr. Carmichael proposes to do about what he has "discovered." I wonder if he would accept as evidence for the defense that the ratio Heads − Tails ÷ Heads + Tails tends to become infinitesimally small as the number of throws increases. We do not "know" that a hyperbole touches its asymptote at infinity, but it is mighty convenient to say so. Or maybe I shouldn't have said that! And how many angels *can* stand on the head of a pin?—ROY K. MARSHALL.

Republished

On page 36 of this issue will be found the poem, "Shall We Speak Out?", which was previously published on page 404 of the May issue in "Comments and Criticisms." We think it merits better treatment than it received in the May issue. The author, Dr. John G. Sinclair, is Professor of Histology and Embryology in the University of Texas School of Medicine at Galveston.—EDS.

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SCIENTIFIC MONTHLY

August 1944

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PUBLISHED BY THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Smithsonian Institution Building, Washington 25, D. C.

To Readers of The Scientific Monthly

THE war is causing the Association serious difficulties in connection with the publication of THE SCIENTIFIC MONTHLY. As every one knows, the war has caused a shortage of paper, and, strange as it may seem, an increase in subscriptions for the MONTHLY.

So much paper is being used directly and indirectly in the war efforts of the United States that the paper allowable for publishing such magazines as the MONTHLY is ten per cent less than the amount they used in 1942. In attempts to meet this reduction by using fewer pages without reducing the amount of printed material the type page of the MONTHLY has been lengthened and widened and the paper has been reduced in weight. However, these steps toward economy in paper have not been sufficient because of an increase in circulation of 30 per cent in about a year.

Some of the increases in subscriptions have come from quite unexpected quarters. For example, nearly 300 subscriptions for the American Airforce Technical Libraries have been received. There are pending also 153 subscriptions for libraries in Latin-American republics, 20 from the Chinese Minister of Education, 9 for the Netherlands and 7 for Russia. These subscriptions call for copies from the beginning of this year, as do other individual subscriptions from residents of this country. The reserve of issues of the MONTHLY from January to July, inclusive, is entirely exhausted because the paper quota made it necessary to keep the printing to a minimum.

What can be done under these conditions? Apparently the only solution is for the readers of THE SCIENTIFIC MONTHLY who do not keep their old copies to cooperate by sending them to the Office of the Permanent Secretary, Smithsonian Institution Building, Washington 25, D. C. Back copies from the beginning of 1944 are much needed and they should be sent by parcel post with the sender's name and address clearly written on the outside so that he can be reimbursed for the expense of shipping. The Office of the Permanent Secretary will be grateful for any contributions of back numbers of the MONTHLY to help tide over the present emergency.

KEEPING UP WITH
Electricity

TRADITIONALLY a welder is surrounded by the haze of smoke. Now a portable Precipitron*, the electrostatic air cleaner, is used by industry to eliminate the welding smoke. The unit clears 600 cubic feet of air per minute.

COUNTING THUNDERBOLTS is the task of a new device which has been thrown into the campaign to protect power lines from damage by lightning. It consists of a saw-toothed and a straight-edged strip of metal foil between two layers of transparent plastic, and is about the size of a playing card. When lightning strikes a power line, a bit of the lightning is deflected to the foil, jumps the gap from one tooth to the straight-edge. In so doing it scorches a black spot on the plastic and also burns away that saw-tooth, so that the next discharge must travel by another path. No two teeth are the same size; each discharge picks the shortest path and thus is registered only once.

ARCHERY AND ELECTRONS are working together in that most modern of scientific instruments, the electron microscope. Quartz filaments 1/30,000 of an inch in diameter—one-sixteenth the thickness of a human hair—are used to calibrate the magnifying power of these microscopes. Westinghouse engineers have found that a modification of the medieval cross-bow is the simplest and most efficient device for drawing out molten quartz into such a filament before it can cool or harden.

• • •

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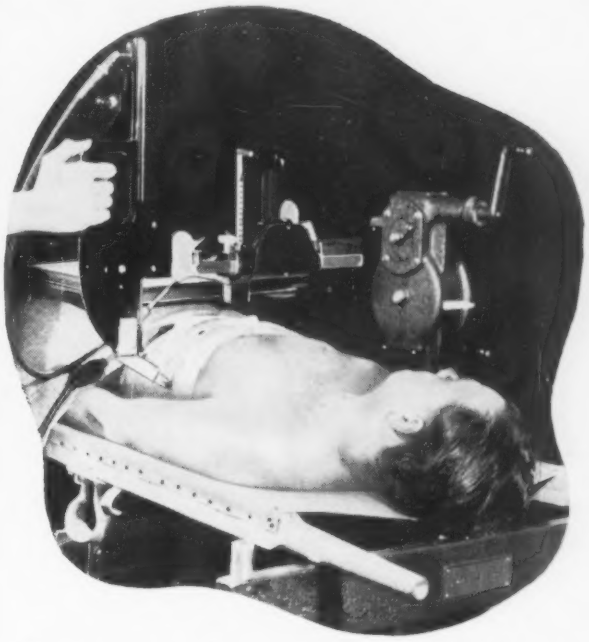

Surgery by triangulation

The life of a soldier wounded by a bullet or shell fragment may depend on the speed with which the metal can be located and removed.

Today, in army field hospitals, *only one minute* is required to discover the fragment and locate it in two planes, incidentally giving the surgeon two points at which incision may be made and also the correct angles and depths beneath the skin.

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THE SCIENTIFIC MONTHLY

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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Founding and Organization

IN 1848, on September 20, the Association was formally organized and held its first meeting; in 1874 it was incorporated under the laws of the Commonwealth of Massachusetts and given the right to receive, purchase, hold and convey property. Its governing body is a Council, now having 255 members.

The Association is national in scope, with membership open to the whole world on equal terms, and its interests include the broad fields of the natural and the social sciences. Its varied activities are carried on under 16 sections with which 189 affiliated and associated societies, having a combined membership of nearly a million, cooperate in organizing programs for its meetings.

Members and Meetings

All persons engaged in scientific work, all who find pleasure in following scientific discoveries, all who believe that through the natural and social sciences a better society may be achieved are eligible for membership in the Association. From its founding, the most distinguished of American scientists, including every American Nobel Laureate in science and every president of the National Academy of Sciences, have been members. The names of many university presidents, of eminent scholars in widely different fields, and of men notable for public service, including a United States Senator, a Justice of the Supreme Court, and a former president of the United States, are now on its roll of more than 25,000 members.

The Association's meetings are field days of science attended by thousands of participants at which hundreds of scientists vie with one another for the pleasure and the honor of presenting results of researches of the greatest benefit to their fellow men. An enlightened daily press reports their proceedings throughout the country.

Opportunity and Responsibility

A world torn by conflicts and fearful of the future is looking more and more toward scientists for leadership. The opportunity for unparalleled service is theirs and the fact that they have available the only essentially new methods, if not purposes, imposes an equal responsibility. For these reasons it will be the Association's steadfast purpose to promote closer relations among the natural and the social scientists, and between all scientists and other persons with similar aspirations, to the end that they together may discover means of attaining an orderliness in human relations comparable to that which they find in the natural world about them.

MEET THE AUTHORS

A. J. CARLSON, Ph.D., LL.D., hon. M.D., hon. Sc.D., has two imposing titles: Frank P. Hixson Distinguished Service Professor Emeritus of Physiology in the University of Chicago and President of the American Association for the Advancement of Science, the most widely representative scientific society in the world. He is so accustomed to bearing heavy loads of responsibility that he is called "Ajax" by his associates, a highly appropriate nickname suggested also by his initials. Dr. F. R. Moulton, a former colleague of Dr. Carlson, has already introduced Ajax to the readers of THE SCIENTIFIC MONTHLY (Feb., 1944, pp. 165–168).

Capitol Photo Service

CLARENCE S. JARVIS, B.S. in C.E., C.E., M.S.E., Ph.D., is engaged in matters of strategic intelligence in the Office of the Chief of Engineers, War Department, Washington, D. C. He was born in 1880 in St. George, a little town in the southwest corner of Utah. Here he grew up on horseback. His love of the great open spaces caused him to choose civil engineering as a profession and, after graduating from the University of Missouri in 1906, his private practice did take him outdoors to direct many important construction jobs. During World War I he was a Captain of Engineers. He early became known as an authority on problems of stream flow and flood control, and in 1927 the American Society of Civil Engineers awarded him the J. James R. Croes Medal for his paper "Flood Flow Characteristics." In the same year he took his doctorate at American University. Since 1929 he has served the Corps of Engineers, the U. S. Geological Survey and the Soil Conservation Service. Dr. Jarvis is a gentleman of the old school. Vigorous and athletic, he has played polo and still rides and runs.

John C. Gifford, D. OEc., is Professor of Tropical Forestry at the University of Miami, Florida (see p. iv of the preceding issue).

Books of Lasting Interest

INTRODUCTORY ASTRONOMY

By J. B. Sidgwick with a preface By Clyde C. Fisher

A fascinating summary of modern astronomical knowledge and a guide to the stars; also describes individual constellations; tells how to find them and how to discover many other objects of special interest to the sky-minded who possess binoculars. Illustrated with 47 star maps, a lunar map, and four maps showing the constellations of each season. **$2.50.**

DICTIONARY of WORLD LITERATURE

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A most interesting reference work in dictionary form, which will add much to your enjoyment of reading and play-going, and enrich your general culture. Covers the origin and history of all the various forms and techniques and criticism in the literary arts of all countries, from classic times down to the present. "Probably has no equal in any language . . . indispensable to all colleges, libraries, magazine and newspaper offices and to individuals occupied with literature" (American Mercury). "One of the few Dictionaries I enjoy reading in bed" (Manuel Komroff). **$7.50.**

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Now for the first time there is available in English a large representative cross-section of The TALMUD. As Rev. John LaFarge, S.J., Executive Editor of AMERICA says ". . . a precious acquisition for Biblical scholarship and for general culture . . . will help to dispel misconceptions . . . and will enable the non-Jewish world to become acquainted with this ancient historic document at first hand." **$3.00.**

TWENTIETH CENTURY PHILOSOPHY

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Now—a clear view of the philosophies that shape the world. Twenty-two essays which illuminate the whole field of modern philosophical investigation. Contributors include such prominent thinkers as John Dewey, Roscoe Pound, George Santayana, Bertrand Russell, Jacques Maritain and others. The principles and thought expressed cover a wide range, from the Philosophy of Life, of Science, of History, of Art, the Humanism of St. Thomas, Logic, and Metaphysics, to the Philosophies of China and the Dialectic Materialism emanating from the U.S.S.R. **$5.00.**

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NEW BOOKS*

Plastic Horizons. B. H. WEIL and VICTOR J. ANHORN. 169 pp. Illus. 1944. $2.50. Jaques Cattell.

Recognizing popular interest in plastics, the authors have written this little book for persons who want to know what plastics really are, what role they play now among structural materials, and what uses may lie ahead for them. Such books are important for adult education.

Electronics; Today and Tomorrow. JOHN MILLS. 178 pp. Illus. 1944. $2.25. D. Van Nostrand.

Like plastics, electronics has become a name familiar to a curious public; and here again we have an attempt to explain the essential concepts, instruments, and applications of a new technology. The extensive military uses of electronics are omitted. Television and electronic microscropy are discussed.

Man Does Not Stand Alone. A. CRESSEY MORRISON. 107 pp. 1944. $1.25. Fleming H. Revell.

"The first chapter of Genesis contains the real story of creation . . ." so writes the author, now in his eightieth year. This is an argument for the compatibility of science and the supernatural. The author is a well-known business man in chemical industry and has had many connections with scientists.

Sumerian Mythology. S. N. KRAMER. xiv + 125 pp. Illus. 1944. $2.00. American Philosophical Society.

The subtitle calls this book "A Study of Spiritual and Literary Achievement in the Third Millenium B.C." Many fine illustrations of cuneiform script on clay tablets are given. The bulk of this book comprises translations and interpretations of this curious script.

Mitosis. FRANZ SCHRADER. x + 110 pp. Illus. 1944. $2.00. Columbia University Press.

A monograph on the movements of chromosomes in cell division, this book is an inventory of present knowledge written by a specialist for specialists. It covers in detail researches of the last twenty years. The book is illustrated chiefly by line drawings.

Rebel without a Cause. ROBERT M. LINDNER. xiii + 296 pp. 1944. $4.00. Grune & Stratton.

All but 43 pages of this book is a verbatim report of the talk of a hypnotized criminal, partly at random and partly in response to questions and suggestions of the author. Forty-six sessions were required to explore the criminal's mind in this manner, called "hypnoanalysis."

The Woods Hole Marine Biological Laboratory. FRANK R. LILLIE. ix + 284 pp. Illus. 1944. $4.00. University of Chicago Press.

Because the reputation of the Marine Biological Laboratory has spread far and wide, biologists in the outer darkness will seek the illumination of Dr. Lillie's story; those among the elect will gloat over it. The story of the Woods Hole Oceanographic Institution is also given.

* Orders for the books noticed above should not be sent to THE SCIENTIFIC MONTHLY or the A.A.A.S., but to your bookseller or the publisher.

MEET THE AUTHORS, Continued

ENRIQUE BELTRÁN is Professor of Zoology in the University of Mexico and Head of the Department of Protozoology in the Mexican Institute of Public Health and Tropical Diseases. He was born in Mexico City in 1903 and went to school there until he graduated in 1926 from the University of Mexico, having concentrated in natural sciences. The holder of a Guggenheim Fellowship in 1932 and 1933, he chose to study protozoa in the laboratory of Professor G. N. Calkins at Columbia University. In 1934 Professor Beltrán founded and became the first Director of the Biotechnical Institute of the Mexican Department of Agriculture. From 1937 to 1939 he was Chief of Secondary Education in the Federal Department of Education. Prominent in Mexican science, Professor Beltrán is a member of the Mexican National Academy of Sciences and the National Academy of Medicine. He is also Permanent Secretary of the Mexican Society of Natural History and the editor of its Journal.

CARL F. TAEUSCH, Ph.D., since 1935 has been head of the Division of Program Study and Discussion, Bureau of Agricultural Economics, U. S. Department of Agriculture, Washington 25, D. C. Born in Ohio in 1889, he graduated from Princeton in 1914 and took his doctorate in Philosophy at Harvard in 1920. He taught philosophy at the University of Chicago, Tulane, and Iowa, and business ethics at Harvard. Dr. Taeusch was formerly Managing Editor of the *International Journal of Ethics* and of the *Harvard Business Review*. His numerous publications include two books: *Professional and Business Ethics*, 1927, and *Policy and Ethics in Business*, 1931. One would not suspect that this electric gentleman is a grandfather.

E. W. GUDGER, Ph.D., should need no introduction to the readers of THE SCIENTIFIC MONTHLY; but if this famous ichthyologist is still unknown to you, see page iv of the April issue, 1944.

MEET THE AUTHORS, Continued

REAR ADMIRAL J. A. FURER, USN, has been the Coordinator of Research and Development for the Navy since 1941. He was appointed to the U. S. Naval Academy from Sheboygan, Wisconsin, and graduated in 1901. After cruises on the USS *Indiana* and on the USS *Shubrick*, he entered the Construction Corps of the Navy and took a post-graduate course in naval construction at the Massachusetts Institute of Technology, from which he received the degree of Master of Science in 1905. His first assignment to Construction Corps duty was at the New York Navy Yard. While at that Yard he laid out the shops for the new Charleston Navy Yard, South Carolina, subsequently becoming the first manager of the Yard. Later he planned and installed the machinery for the shops at the new Naval Station, Pearl Harbor. In March, 1915, while he was on this duty, the submarine *F-4* sank off Honolulu. He planned and supervised the raising of the vessel from a depth of 304 feet of water, the greatest depth from which any ship has ever been raised. He invented a novel type of submersible pontoon for use in the final stages of the salvage work. Such pontoons are now standard equipment for all submarine bases and were used in raising the *S-51*, the *S-4*, and the *Squalus*. While on duty in the Bureau of Construction and Repair of the Navy Department during World War I, he had charge of the designing and building of small craft, the most important being the 110-foot subchaser and the Eagle boats. He was awarded the Navy Cross for his work in that connection. After World War I he served on the staff of Admiral Hugh Rodman, USN, Commander-in-Chief of the Pacific Fleet. While he was a member of the U. S. Naval Mission to Brazil (1923 to 1927), he laid out a new Navy Yard for the Brazilian Government in Rio de Janeiro. He was manager of the Navy Yard Cavite from 1928 to 1930 and of the Philadelphia Navy Yard from 1930 to 1935. From 1935 to 1938, Rear Admiral Furer was on the staff of the American Embassies in London, Paris, Rome, and Berlin. In addition to the Navy Cross, Spanish War Medal and Victory Medal, Rear Admiral Furer has a number of foreign decorations. He has contributed frequently to technical magazines and has written numerous articles on naval subjects.

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American Association for the
Advancement of Science
Smithsonian Institution Building,
Washington 25, D. C.

MEET THE AUTHORS, Continued

GUSTAV BERGMANN, Ph.D., J.D. (University of Vienna) has been connected with the State University of Iowa since 1939 and is at present a lecturer in philosophy and psychology. Before coming to this country in 1938, he was a member of the now famous *Vienna Circle*, a group of philosophers and scientists who gathered around the late Professor Schlick and Professor Carnap (now at the University of Chicago). The "Circle" cultivated mainly the philosophy of science, mathematical logic, and what is now known as the philosophy of language or semiotics. Dr. Bergmann's early publications dealt with differential geometry, topology, and axiomatics; his later publications were concerned with epistemology and scientific method. More recently he has been publishing jointly with Professor K. W. Spence on the foundations of psychology. Dr. Bergmann married a native American and recently became an American citizen.

W. A. MCCUBBIN, M.A., is Senior Plant Pathologist in the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, Washington, D. C. He is attached to the Division of Foreign Plant Quarantines, but serves in an advisory capacity to the Bureau as a whole. Mr. McCubbin was born in Ontario, Canada, in 1880, graduated in biology from the University of Toronto in 1908, and took his M.A. there the following year. He continued to study and teach until 1912 when he took charge of a laboratory at St. Catharines, Ont., on fruit disease problems. From 1919 to 1930 he was Assistant Director and Pathologist of the Pennsylvania Bureau of Plant Industry at Harrisburg. Since 1930, he has been engaged in Federal work on plant quarantines, including four years in Puerto Rico. Mr. McCubbin is a meticulous writer and is interested in applying his literary skill not only to drawing up plant quarantine regulations but also to public education. A nature lover, his varied hobbies take him outdoors.